Flight
26 JULY 1957

ONE SHILLING & SIXPENCE

FLIGHT

OFFICIAL ORGAN OF THE ROYAL AERO CLUB

AERO ENGINES OF THE WORLD

Mixed

power plant

interception

by

SAUNDERS-ROE

SAUNDERS-ROE LIMITED

OSBORNE

EAST COWES

ISLE OF WIGHT

FORGED BLADES FOR GAS TURBINES

BY GARRINGTONS

These blades are precision forged in the new forging shop specially built and specially equipped, with the largest capacity in Europe for the production of forgings for the Aircraft Industry.

The materials forged include

STAINLESS STEELS

ALUMINIUM ALLOYS

ALUMINIUM BRONZES

NICKEL ALLOYS

AND TITANIUM ALLOYS

GKN

GARRINGTONS LIMITED, BROMSGROVE, WORCS. & DARLASTON, STAFFS.

A general purpose brain for the aircraft industry

The Short analogue computor

runs through in hours a range of solutions to differential equations which might take weeks to work out on paper

proves its value in the investigation of aircraft flutter problems and the stability of large aircraft

produces results graphically—either as traces on a cathode-ray tube or plotted on a paper chart

is simply built and can be handled by an operator without specialised electronic knowledge

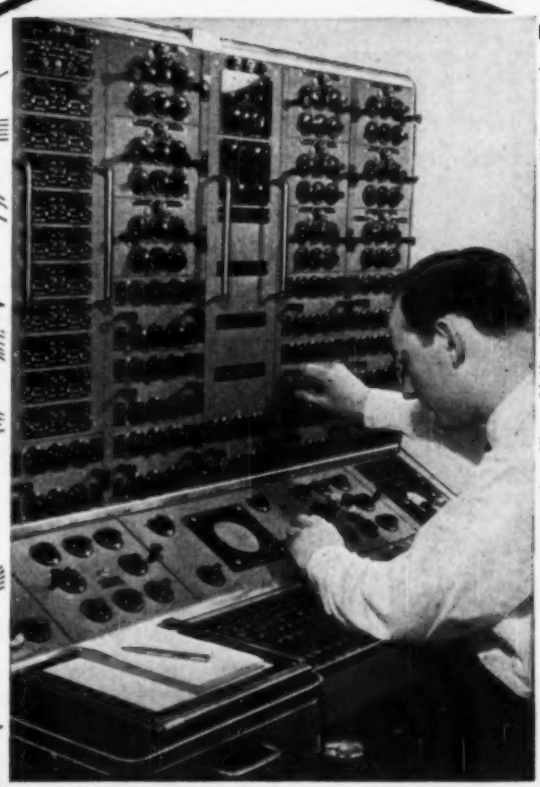
is made up of easily movable units which can be changed to suit different problems

is fully described in a new brochure which will be sent to you on request.

Short BROTHERS AND HARLAND LTD

Europe's leading manufacturers of analogue computors

Computor Sales Department, 208a Regent Street, London W.1 Regent 8716



ARRINGTONS LIMITED, BROMSGROVE, WORCS. & DARLASTON, STAFFS.

Around the World

PRATT & WHITNEY AIRCRAFT'S JT4—
Free world's most powerful production turbojet

19 airlines have ordered Boeing 707 or Douglas DC-8 transports with Pratt & Whitney Aircraft jet engines

Air France
Japan Air Lines
KLM Royal Dutch Airlines
Qantas Empire Airways
Sabena Belgian World Airlines
Scandinavian Airlines System
Swissair
Transports Aeriens Intercontinentaux
UAT-Aeromaritime
American Airlines
Braniff International Airways
Continental Air Lines
Delta Air Lines
Eastern Air Lines
National Airlines
Pan American-Grace Airways
Pan American World Airways
Trans World Airlines
United Air Lines

Volume production of the JT4 engine—most powerful in the free world—is under way at Pratt & Whitney Aircraft. Rated in the 15,000-pound thrust class, the JT4 will power a majority of the Boeing 707 and Douglas DC-8 jet airliners ordered by the leading airlines of the world.

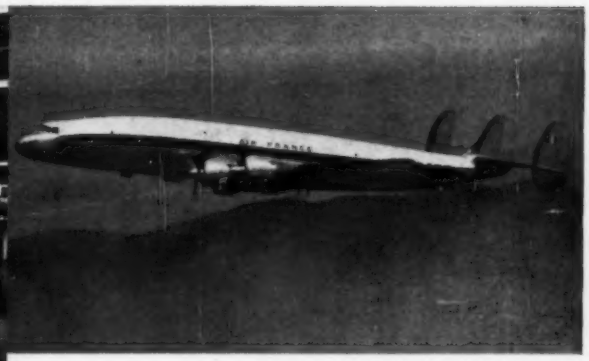
Recently certified by the U.S. Civil Aeronautics Administration for airline use, the JT4 is the commercial version of the J-75, which will power a number of high performance military aircraft. These include the Republic F-105 fighter, production models of the Martin P6M seaplane and other aircraft yet to be announced.

The JT4's basic configuration stems from the successful twin spool, axial-flow design of the famed J-57 and JT3. Despite its 50 per cent increase in thrust, the JT4 is only slightly larger than the JT3, with a lower specific weight and outstandingly low specific fuel consumption.

FRENCH AIRLINES PREPARE FOR JET AGE: The most recent jet airliner orders are those of the French independent lines, Transport Aeriens Intercontinentaux and Union Aeromaritime de Transport, which both have ordered Douglas DC-8s with Pratt & Whitney Aircraft JT4 engines. Meanwhile, Air France has increased to 17 its order for Boeing 707s. These also will be equipped with JT4 engines.

ARRINGTONS LIMITED, BROMSGROVE, WORCS.

with United Aircraft



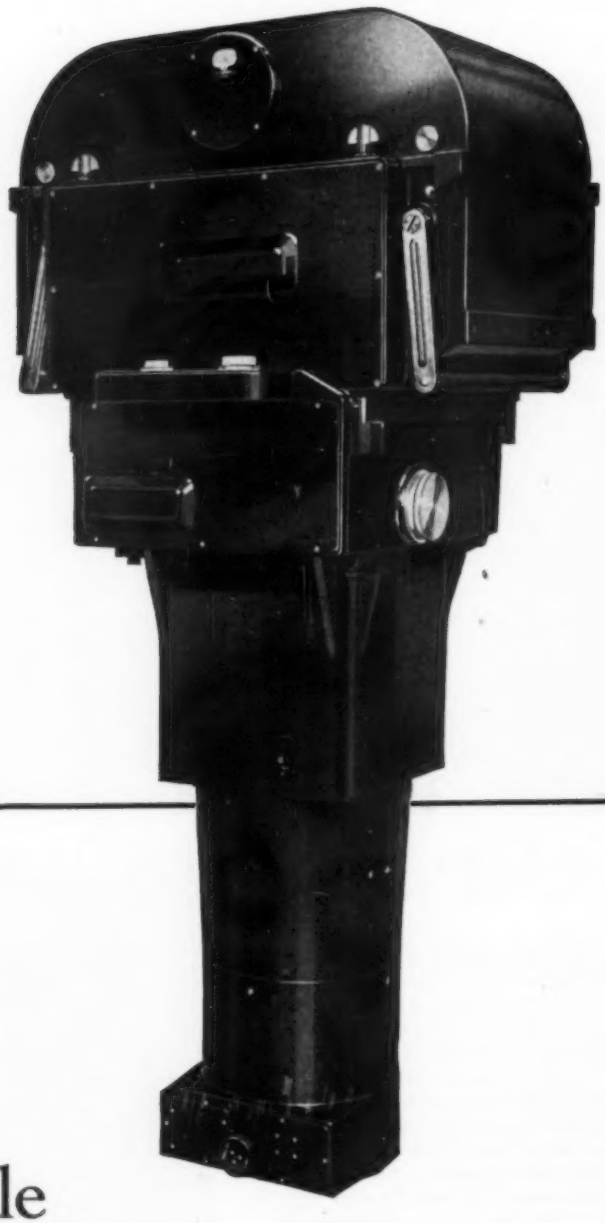
NEW PROPELLERS specifically designed for advanced versions of the Lockheed Super Constellations are being produced by Hamilton Standard. To meet increased gross loads, the hub and solid aluminum alloy blades have been strengthened. Airlines using the new propeller, designated 43H60, include Air France, Air India, Avianca, Cubana, Iberia, KLM, LAI, LAV, Lufthansa, TAP, Thai Airways, and Varig, in addition to U.S. operators.

COMMERCIAL helicopter operators are now receiving deliveries of 12-passenger Sikorsky S-58s. The two S-58s illustrated were ordered by Humble Oil and Refining Co. to fly between shore bases and oil drilling platforms many miles out in the Gulf of Mexico. They speed the transportation of personnel and priority cargo, replacing slower surface craft. Sikorsky S-58s now provide scheduled passenger service in Belgium, France, Netherlands, and Germany, and in the United States.

UNITED AIRCRAFT EXPORT CORPORATION *East Hartford 8, Connecticut, U. S. A.*

European Offices: *3/5* Warwick House Street, London SW1, England

PRATT & WHITNEY AIRCRAFT *Aircraft Engines*
HAMILTON STANDARD *Propellers and Turbine Aircraft Equipment*
SIKORSKY AIRCRAFT *Helicopters*



F96

The finest air reconnaissance camera available today

for details please write to:

WILLIAMSON

MANUFACTURING COMPANY LTD.

Photographic Engineers

Litchfield Gardens, Willesden Green, London, N.W.10. WMM(B)

Crossley Wire Braid is flying all over the world at speeds up to 1132 miles per hour and heights up to 65000 ft

HENRY CROSSLEY (PACKINGS) LTD., BOLTON, ENGLAND

With a
touch of pride ...
We feel justly proud in having manufactured the prototype main engine cowling, the production line rear cowling door assemblies, oil systems and oil cooler mounting panels.
We shape the things to come

The Abbey Panel & Sheet Metal Co. Ltd.

BAYTON ROAD,
BEDWORTH,
Nr. COVENTRY.
Telephone: BEDWORTH 2071/4

also at
OLD CHURCH ROAD,
LITTLE HEATH,
COVENTRY.
Telephone: COVENTRY 89461

Experts in high class shape panel work Aircraft fabrications and assemblies

Consult ELLIOTT for Guidance and Control Systems

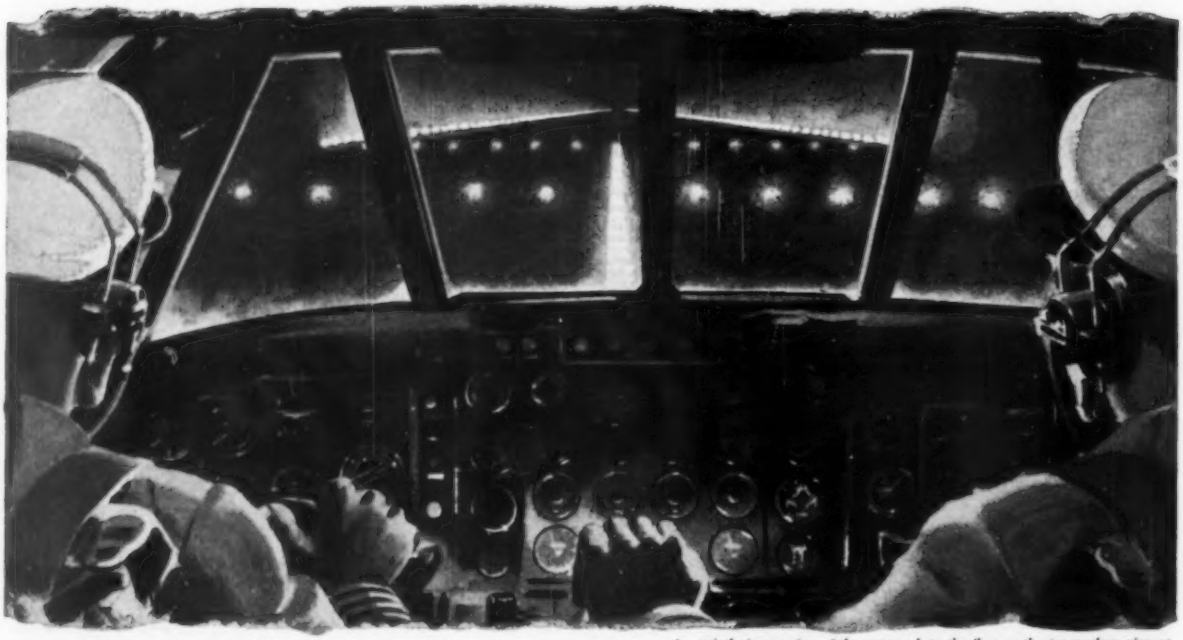
PRINTED CIRCUITS • DELAY LINES • SWEEP FREQUENCY OSCILLATORS • SERVOAMPLIFIERS

"G" CONTROL EQUIPMENT FOR VIBRATION TESTING • SYSTEM SIMULATION AND DATA RECORDING

HYDRAULIC SERVO SYSTEMS • DEMODULATORS • G.W. TRIALS RANGE INSTRUMENTATION

GUIDED WEAPONS DIVISION, ELLIOTT BROTHERS (LONDON) LTD., ELSTREE WAY, BOREHAMWOOD, HERTS. (ELSTREE 2040)

Electrification of the Modern Airport



An artist's impression of the approach to the flare-path at a modern airport

Out of the night sky, the airliner descends in a long and gentle glide. From many miles distant, the location beacon has been picked up. Now, over to port, the identification beacon flashes the airport signal and, ahead, approach lights point the way to the runway lighting. Safely down, the flight is over.

Airport lighting has become a complex science—a far cry from those first night flights made in the beam of car headlamps. And the G.E.C., with its wealth of experience and highly specialised staff, has long been associated with the development of the lighting demarcation system now almost universally standardised. Approach, runway and taxiway lighting layouts, loading and maintenance floodlights, hangar, roadway and car park lighting and ground traffic control systems reflect the vital contribution made by the G.E.C. in this important field.

Lighting, however, is but one facet of the electrification of the modern airport. G.E.C. installations embrace telecommunication systems for aircraft and passenger control, electric cooking equipment for the airport flight kitchens and electrically heated food containers enabling hot food to be served in flight—also equipment for aircraft maintenance and for the maintenance and administration of the airport itself. In addition, the Company supplies the sub-stations, switchgear and circuits that are required for power distribution and lighting control.

Equipment that complies with the standards of the International Civil Aviation Organisation has been installed by the G.E.C. on airports in every part of the world.

G.E.C.

THE GENERAL ELECTRIC CO. LTD., MAGNET HOUSE, KINGSWAY, LONDON, W.C.2

Over two million hours of airline service

Well over two million hours' flying in airline service in all parts of the world . . . that's the new standard of engine reliability set up by the Rolls Royce Dart. As component equipment on this engine, Silvoflex Type 200 Flexible Hose Units have contributed to this triumph . . . have shared every hour of this exceptional performance—all without one failure in service. That's the new standard of flexible hose reliability set up by Silvoflex Type 200.

Silvoflex Type 200 Flexible Hose Unit. Working pressures up to 4500 p.s.i. Temperature range—40°C to 150°C. Wide-bore End-fitting has Lip-seal high pressure sealing zone, low pressure sealing zone, and Interlock anchoring onto standard or fire-proof hose.

Palmer

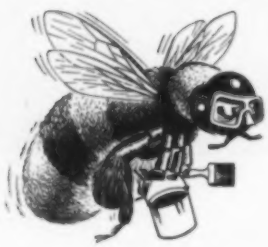
The Palmer Tyre Limited PENFOLD ST. EDGWARE RD. LONDON N.W.8

AERO COMPONENTS • RAMS • VALVES • SILVOFLEX HOSE • X-RAY INSPECTION SERVICE

S1277

DOCKERS' AIRCRAFT MATERIALS

can take it!

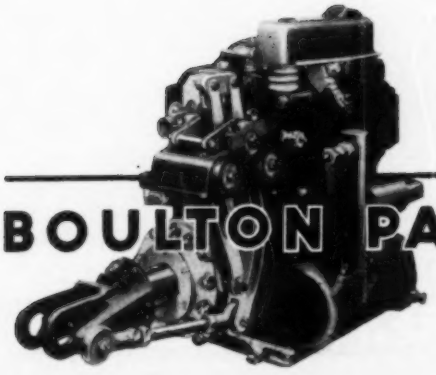


Cumulus at bedtime.
Possibly a shower or two to come—
but nothing to upset a 'Docker finish'.

DOCKER BROTHERS · LADYWOOD · BIRMINGHAM 16

MANUFACTURERS OF SURFACE COATINGS FOR EVERY PURPOSE · OVERSEAS REPRESENTATION THROUGHOUT THE WORLD

The high sensitivity of Boulton Paul Power Controls is independent of aerodynamic loads and enables the units to respond to the slightest displacement of the control column under all conditions of flight



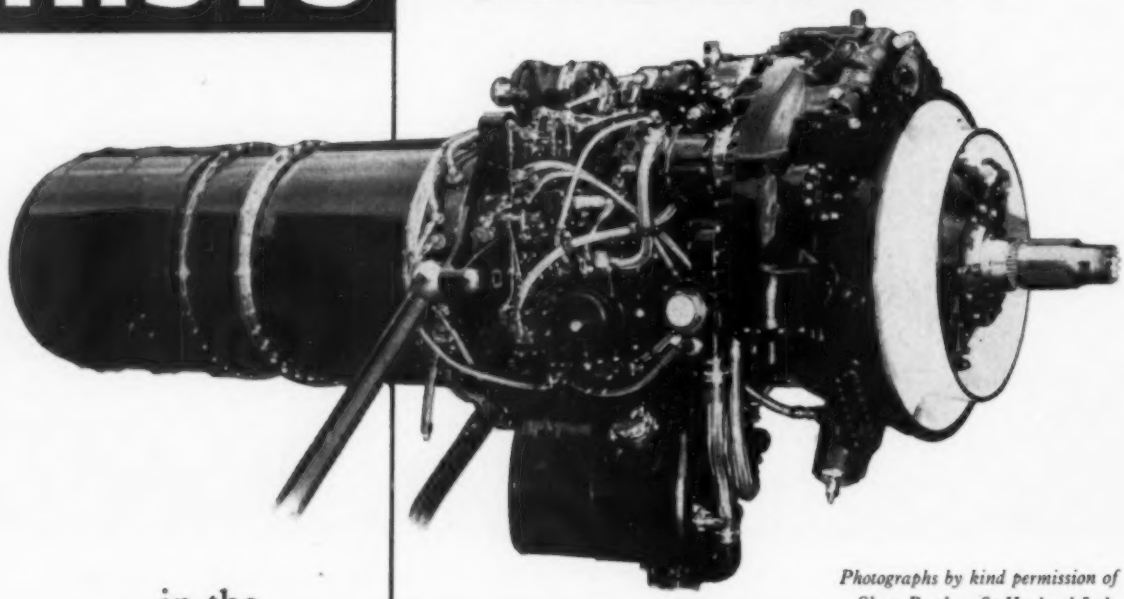
BOULTON PAUL AIRCRAFT LTD.

WOLVERHAMPTON, ENGLAND

The necessity for high quality cables

Short Seamews fitted with the Armstrong Siddeley Mamba.

RISTS CABLES...



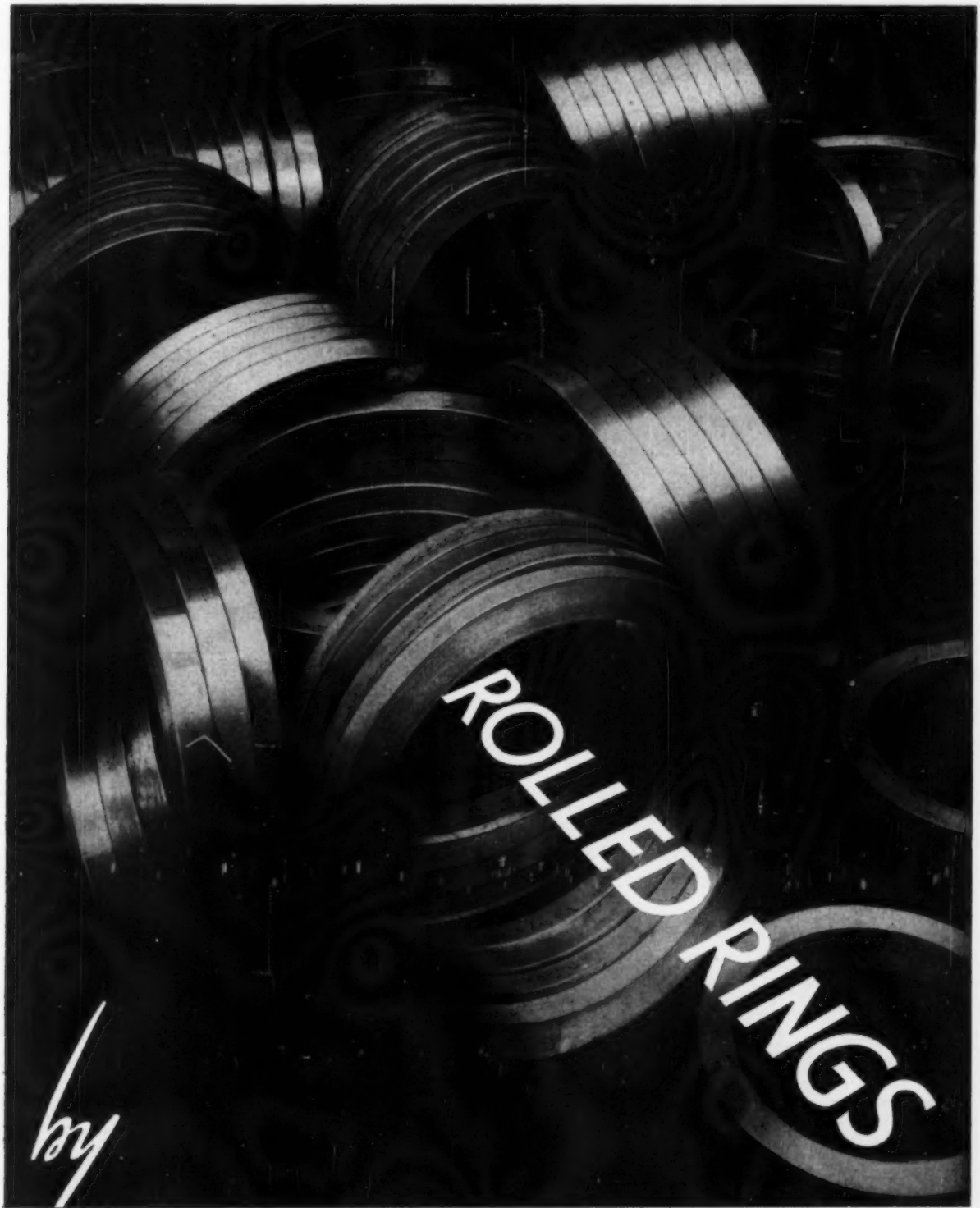
Photographs by kind permission of Short Brothers & Harland Ltd., and Armstrong Siddeley Motors Ltd.

...in the Armstrong Siddeley **MAMBA**

In addition to a wide range of cables, we specialise in the production of many forms of assemblies for the Aircraft Industry. From the engine to communications, instruments, etc., we have developed and made many moulded cable assemblies.

For further details please write to Aero Division

RISTS WIRES & CABLES LTD.
LOWER MILEHOUSE LANE • NEWCASTLE-UNDER-LYME • STAFFS



FIRTH BROWN

ALLOY STEELMAKERS · FORGEMASTERS · STEEL FOUNDERS · HEAVY ENGINEERS

THOS FIRTH & JOHN BROWN LIMITED · SHEFFIELD · ENGLAND

B·A·P

HAVE

HEAD OFFICE AND FULLEDGE WORKS
HOLMES STREET, BURNLEY

REPAIR DIVISION
STONEYHOLME WORKS
GROSVENOR ST., BURNLEY

HALF A MILLION SQUARE FEET OF FLOOR SPACE DEVOTED TO THE MANUFACTURE AND REPAIR OF SHEET-METAL FABRICATIONS OF AIRCRAFT COMPONENTS AND FOR ALL FORMS OF COMBUSTION EQUIPMENT IN HEAT-RESISTING ALLOYS TO THE GAS TURBINE ENGINE AIRCRAFT INDUSTRY.

The normal run of Components comprise—
JET PIPES - EXHAUST UNITS - AIR INTAKES - FLAME TUBES - VAPOUR PIPES - DISCHARGE NOZZLE BOX PANELS - COMBUSTION CHAMBER SHROUDS - INLET BRANCH EXTENSION UNITS - FIREWALL BULKHEAD PANELS - OIL OR DRAIN TANKS - EXPANSION BELLOWS - INSULATION BLANKETS AND CASINGS ETC.,

A portion of the factory is devoted to development work. This section, which is self contained and staffed by skilled craftsmen, specialises in making by hand prototypes for test purposes and operates as it were, some weeks or months in advance of tool produced components.

BRITANNIA WORKS, QUEENSGATE
BURNLEY

ASSOCIATE COMPANY
RENFREW AIRCRAFT AND ENGINEERING CO., LTD.
RENFREW, ONTARIO, CANADA

A.I.D. and A.R.B. approved.

BURNLEY AIRCRAFT PRODUCTS LIMITED

FULLEDGE WORKS — BURNLEY — LANCASHIRE — ENGLAND
Telephone: 3121/2 and 3203 Burnley (3 lines) Telegrams: "AIRCRAFT" Burnley
REPAIR DIVISION: GROSVENOR STREET, STONEYHOLME, BURNLEY. Telephone: 3184
BRITANNIA WORKS, QUEENSGATE, BURNLEY. Telephone: 4102

Associated with
RENFREW AIRCRAFT & ENGINEERING CO. LTD., RENFREW, ONTARIO, CANADA

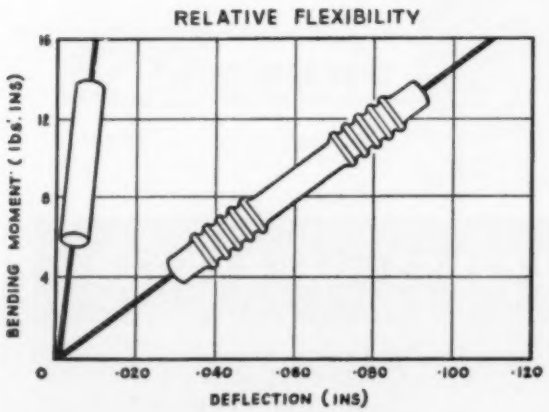
Overcome vibration fatigue

with

'HI-FLEX'

CORRUGATED STAINLESS STEEL PIPE ASSEMBLIES

with acknowledgements to Rolls-Royce Ltd.



The Hi-Flex Organisation presents the successor to Rubber Hose Lines on applications of high temperature installation. Corrugated seamless stainless steel tube assemblies, completely stabilized, ten times as flexible as rigid tubing with no weight penalties. Vibration fatigue eliminated, wide temperature operating range, and will accommodate effects of thermal expansion. Available with Argon Arc welded or brazed end fittings.

OIL FEED ENGINEERING CO. LTD.

10 DENBIGH STREET · VICTORIA · S.W.1

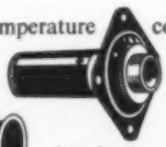
CABIN AIR CONDITIONING . . .

Cabin air conditioning system components including

mass flow and flow rate controllers

electronic or pneumatically-operated temperature controllers

humidity controllers



duct and cabin temperature sensing units

electrically or pneumatically actuated gate or butterfly valves and thermostatic switches have been designed and developed for use in many present-day aircraft, military and civil, to meet the special features demanded by each installation.

CABIN AIR CONDITIONING CONTROL

ANTI-ICING CONTROL

FUEL TANK PRESSURISATION

HOT AIR AND GAS VALVES

ELECTRO-MAGNETIC VALVES

TIME SWITCHES

PRESSURE SWITCHES

PRESSURE REGULATORS

POTENTIOMETERS, ACCELEROMETERS AND PRESSURE TRANSDUCERS

Teddington CONTROLS

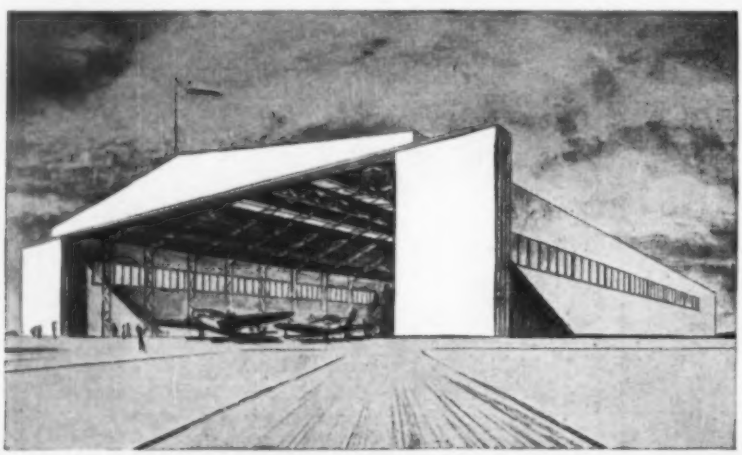
REGD TRADE MARK

TEDDINGTON AIRCRAFT CONTROLS LTD.

MERTHYR TYDFIL, SOUTH WALES. Telephone: Merthyr Tydfil 666

LONDON OFFICE: COLNBROOK BY-PASS, WEST DRAYTON, MIDDLESEX. *Telephone: Colnbrook 502*

TAC 148



Standard designs
200′ 0″ to 30′ 0″ spans

STEEL ECONOMY

SPACE ECONOMY

TROPICAL SHEDS & HOUSES
GODOWNS · BARRACKS · OFFICES, ETC.

We supply and erect in any part of the world.

GENERAL UTILITY **STEEL BUILDINGS** AND **HANGARS**

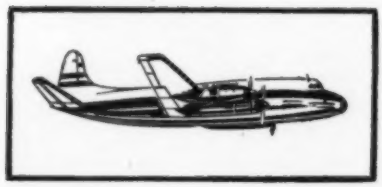
FOR HIRE. Erection masts 30ft. to 180ft. high. Cranes and lifting tackle.

BELLMAN HANGARS

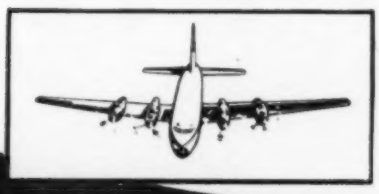
LIMITED

HOBART HOUSE, GROSVENOR PLACE, LONDON, S.W.1 *Tel:* SLOANE 5258 *Cables: Unistruct, Sowest*

WING-STOWED LIFERAFTS



VISCOUNT



BRITANNIA

AUTOMATIC SAFETY is today a built-in feature of modern air travel, with gas-inflated liferafts complete with all necessary aids to survival, stowed in the wings and fuselage. Where such equipment is concerned, the unrivalled experience of the R.F.D. Company—first manufacturers of inflatable liferafts in the world—will ensure a rapid solution to your own particular problem.

THE WORLD LOOKS TO

R·F·D COMPANY LTD

M.O.S. Design Approved and A.R.B. Design Approved
R.F.D. COMPANY LIMITED, GODALMING, SURREY, ENGLAND
Overseas Companies in: N. IRELAND · AUSTRALIA
CANADA · AFRICA · HOLLAND · SWEDEN · FRANCE · GERMANY

B

AVRO VULCAN

now in squadron service with the R.A.F.

The Avro Vulcan, the world's first 4-jet delta bomber, has entered the Royal Air Force for full squadron service. Behind the recent Air Ministry announcement lies a brilliant chapter of aeronautical progress that marks the beginning of a new era in Britain's air power. With its near sonic speed, its great range and altitude and its large carrying capacity, the Vulcan can deliver a bigger bomb load faster, higher and further than any other aircraft. Add to this its fighter-like manœuvrability, exceptional safety and pleasant handling characteristics and you have the reasons why the Vulcan is the most effective bomber in service today. But that is not all . . . the Vulcan has a great development potential . . . it has been engineered to allow for new operational requirements which can be met without major alteration to the basic design. In the tough testing ground of the R.A.F. on routine exercises and on long-range training flights, the Vulcan is already showing its paces. Like its illustrious predecessors from the Avro stable—the Lincoln, the Lancaster, the Anson, the 504 and many others—the Vulcan is destined to become one of the world's really great aircraft.

A. V. ROE & CO. LIMITED — MANCHESTER / ENGLAND

Member of The Hawker Siddeley Group/Pioneer...and World Leader in Aviation

FIRST AERONAUTICAL WEEKLY IN THE WORLD FOUNDED 1909

FLIGHT
and
AIRCRAFT ENGINEER

No 2531 Vol 72 FRIDAY 26 JULY 1957

Editor
MAURICE A. SMITH D.F.C. and BAR

Associate Editor
H. F. KING M.B.E.

Technical Editor
W. T. GUNSTON

Production Editor
ROY CASEY

Iliffe and Sons Ltd
Dorset House
Stamford Street
London, S.E.1
Telephone · Waterloo 3333 (60 lines)

BRANCH OFFICES

Coventry
8-10 Corporation Street
Telephone · Coventry 5210

Birmingham 2
King Edward House, New Street
Telephone · Midland 7191 (7 lines)

Manchester 3
260 Deansgate
Telephone · Blackfriars 4412 (3 lines)
Deansgate 3595 (2 lines)

Glasgow C.2
26B Renfield Street
Telephone · Central 1265 (2 lines)

Toronto 1, Ontario
Thomas Skinner of Canada, Ltd.
67 Yonge Street
Telephone · Empire 6-0873

New York 6, N.Y.
Thomas Skinner and Co. (Publishers), Ltd.
111 Broadway
Telephone · Digby 9-1197

SUBSCRIPTION RATES
Home and Overseas · Twelve Months, £4 10s. U.S.A. and Canada $14.00

In this issue

98 From All Quarters
101 Civil Aviation
103 Russian Contenders
104 Handling the Super Aero
106 Here and There
107 Aero Engines 1967
111 Aero Engines 1957
144 Correspondence
145 The Industry
146 Service Aviation

Hard Bargaining

ANGLO-AMERICAN discord, whenever it arises, is always regarded as news, so much so that it is sometimes suspected when it does not in fact exist. Two discords are evident at the moment, both of them in the sphere of civil air transport. Strong words have been flying across the Atlantic, and it is as well to examine them in their contexts.

Discord No. 1 concerns traffic rights. "It's not the Germans or the Swiss who won't let T.W.A. fly Frankfurt-Zurich," said (in so many words) a member of the U.S. Senate: "It's the British."

The context of this quotation is the bargaining which has been going on between the governments of the two countries over traffic rights, under the terms of the Bermuda Agreement. B.O.A.C. would like trans-Pacific rights between California and Australia. The Americans are prepared to grant them, but in return they want Trans World Airlines to be able to lift traffic out of London to the many points on its network in Europe and the East. This, feels the British government, would seriously affect B.E.A.'s European business and B.O.A.C.'s Middle and Far Eastern traffic. The Americans also want traffic rights at Hong Kong for Northwest Airlines. The implications of this, our own government feels, would be that Northwest, a trans-Pacific operator, could link with T.W.A.'s Eastern services and further jeopardize B.O.A.C.'s Eastern business.

There the matter rests—further evidence of the political climate in which air commerce has to work. It would be good to feel that it is the British who are seeking a way out of the *impasse:* although it may seem on this occasion that we hold most of the cards, it is certain that in the future, if Britain's share of international air transport is to expand as it should, we shall be seeking more than we can give.

Discord No. 2 concerns airworthiness. Lord Brabazon, chairman of the Air Registration Board, has referred to "a battle of special requirements, some of them very, very silly." It was good to hear someone speak up at last on this topic. Man to man, the A.R.B. and C.A.A. talk as engineers, insulated from politics and big business. It would be a pity if their inevitable differences of technical opinion were to be turned to other ends.

The Big Top

NOT long ago there was a great pother about the number of admirals deemed necessary to run our diminishing Royal Navy. Now, in answer to a Parliamentary question, the Under-Secretary of State for Air has had to admit that the Royal Air Force is even more top-heavy. For every officer of air rank there are only 761 other ranks; whereas the ratio for each rear admiral or above is the comparatively respectable figure of 930, and every major-general or above heads a veritable army of 2,100 men. How does the R.A.F. come to have such a flourish of air officers, and can all this scrambled egg be digested by a slimmer Service? One of the Under-Secretary's questioners suggested that when an air marshal was appointed to a guided-missile post there should be a corresponding reduction in manned-aircraft posts, and Mr. Orr-Ewing spoke of "a most careful survey."

It is quite understandable that the R.A.F., with its brilliant war record and its very high standards of selection, should throw up so many first-class senior officers; even with an inflated establishment there is not nearly room for everyone at the top and many men of high ability must leave the Service disappointed at not having got there. Nevertheless, the ratio of one air rank officer to 761 other ranks is too high, and the Air Minister should indeed examine all appointments to see if they are justified. Otherwise the R.A.F. is going to find itself in the Gilbertian situation of everyone being somebody and no one anybody. Present prospects, of course, are encouraging for the air officers of tomorrow, training at Cranwell or Halton—for with a ratio of 1:761 they have more than a sporting chance of finding the proverbial baton in their small-kit, and may confidently dream of scrambled egg when they hang up their hats for the night.

FROM ALL QUARTERS

The Oman Revolt

AS we go to press, R.A.F. Venoms at Sharjah, on the Trucial Coast, are ready for action against the rebels who are defying the Sultan of Muscat and Oman. The first move will be the dropping of warning leaflets, followed by a demonstration airstrike; if this is ineffective, cannon and rocket action against selected targets is likely. Four Beverleys, each of which can carry 90 fully armed soldiers and land them on any suitable desert area, are at the disposal of the A.O.C. British Forces, Arabian Peninsula (A.V-M. L. F. Sinclair). They have arrived at Nairobi, East Africa—two from Aden and two from the U.K.

Air-to-Air Atomics

AN atomic-headed Douglas Genie air-to-air missile was launched from a Northrop F-89 Scorpion fighter over Yucca Flats, Nevada, on July 19. This was the first live firing of the missile—presumably of the type formerly known as Ding Dong. The explosion occurred at a height between 20,000 and 30,000ft, and five officers of the U.S.A.F. Air Defence Command, posted on the ground directly beneath, did not require any protective shield. The Genie was launched "by remote control" and not by the pilot of the Scorpion.

Borzoi and Red Dean for Farnborough

IT is pleasing to reiterate that this year's S.B.A.C. Flying Display and Exhibition, to be held at Farnborough during the first full week in September, is to be the biggest and best yet. A special enclosure adjacent to the exhibition building (housing 350 stands) will be set aside for guided missiles, the majority of which will be available for export. In addition to the Fairey Fireflash, de Havilland Propellers Firestreak, Armstrong Whitworth Sea Slug, Bristol Bloodhound and English Electric Thunderbird, there will be a Bristol Bobbin, complete with parachute, a Bristol Borzoi, and the Vickers-Armstrongs Red Dean. The Borzoi is described as a test vehicle for advanced research, and of the Red Dean the makers will only say that it is "suitable for installation in all-weather fighters." Fairey Aviation will be showing a Jindivik pilotless target, for which they hold sales rights in this country.

Gliding Height Record

A CLIMB to 29,700ft in a Weihe sailplane was achieved by Sgt. John S. Williamson after an aero-tow from Lasham on July 19. The net gain of height was 27,100ft. Subject to confirmation, these are new U.K. records for both absolute altitude and gain of height.

The previous U.K. height records were those set up by Derek Piggott, who flew a Skylark 2 to 22,800ft in 1955. More recently, F/L. A. H. Warminger reached 30,000ft in a Skylark 3, but his barograph failed to function above 20,000ft and the flight could not be confirmed as an official record.

Exercise Shopwindow

A COMPREHENSIVE demonstration of the capabilities and techniques of the Royal Navy was arranged for a party of selected members of the Press in H.M.S. *Albion* last week. The morning was devoted to various demonstrations by surface craft and a submarine, and a Whirlwind picked up distressed dummy pilots from the sea.

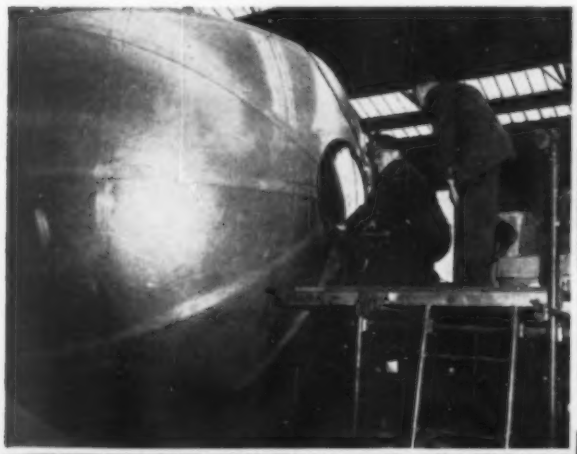
The afternoon was given over to a splendid display of gunnery, rocketry and bombing by Sea Hawks, Gannets and Sea Venoms. All missiles were aimed at a splash target towed close at hand by *Grenville*. Catapult take-offs and arrested landings were exhilarating to watch; and the landing mirror was used with great success. The long and arduous deck drill was the prettiest piece of team work one could hope to see. *Ark Royal* was steaming nearby on trials work and launched both Sea Vixen and Scimitar for very brief appearances over *Albion*. The afternoon ended with a very smooth formation aerobatic display by four Sea Hawks.

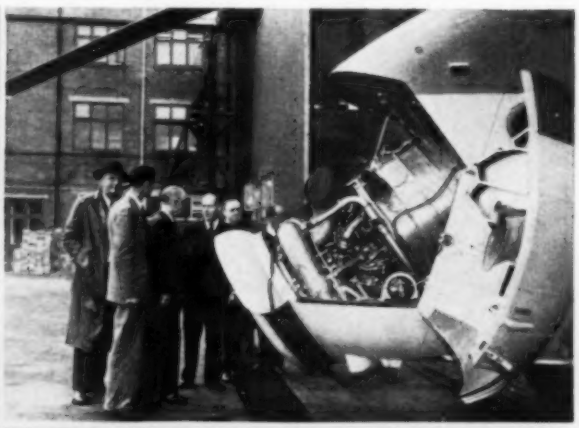
E.P.9's North African Tour

AN Edgar Percival E.P.9 was recently flown by Mr. Harold Best-Devereux, chief of sales of Edgar Percival Aircraft, Ltd., on a sales tour of North Africa which involved altogether a distance of 5,000 miles and over 40 hours' flying time.

The aircraft was flown out over France and down the Spanish coast to Carthagena, then on to Oran, where a day's demonstra-

PRODUCTS AND PERSONALITIES—a quartet of news-pictures from the industry: (Top left) Air Marshal Sir Andrew McKee, A.O.C.-in-C. Transport Command, visiting Armstrong Whitworth Aircraft, examines a water-pressure test-section of the A.W.650 fuselage. (Top right) at Westlands, Mr. Aubrey Jones, Minister of Supply—fourth from left—discusses with Mr. E. C. Wheeldon (managing director) the Napier Gazelle installation in the Wessex. (Bottom left) Martin-Baker Mk 5 fully automatic ejection seats ready for delivery to the U.S. Navy and U.S.A.F. (Bottom right) First of the 22 Hawker Sea Hawks for the Royal Netherlands Navy was collected from A.W.A.'s Bitteswell Airfield on July 18; l. to r. are Baron van Boetzelaer, who formally accepted the aircraft; Lt-Cdr. R. J. Idzerda, who flew it home and will command the first squadron; Lt. C. Timmer, technical liaison officer; S/L. E. G. Franklin, A.W.A. chief test pilot; and Capt. Edward F. Metzger, U.S.N.





GUN PORTS in England's wooden walls bespoke our sea-power in the brave old days. Even now the Royal Navy is not without them, as witness this new picture of the Vickers-Supermarine Scimitar carrier-borne fighter/bomber (two Rolls-Royce Avon), wherein the blast channels and ports for the four 30 mm Aden guns are much in evidence. Formidable combinations of armament stores and tanks can be carried externally.

tions were given. It was taken next to Algiers and there examined and demonstrated for three days, some 48 people being given flights in one hectic two-hour period, when the aircraft was operating from a 200 yd × 80 yd parking area. With full tanks and the pilot and five passengers the E.P.9 took off consistently in 105 yd and landed in about 60 yd.

From Algiers the aircraft went to Bone, where it was demonstrated at two airfields (during all this time cruising at 11 gal/hr); it was next taken to Tunis and then to Cagliari, Sardinia, for a night-stop before returning to England *via* Lyons.

Transcontinental Crusader

ON July 16 a U.S. Navy Crusader piloted by Maj. John Glenn of the Marine Corps flew from Los Alamitos in California to Floyd Bennett Field, New York—a distance of 2,460 miles—in 3 hr 23 min 8.4 sec, an average speed of 726 m.p.h. This time was 21 minutes less than the transcontinental record set up by Lt-Col. Robert Scott on March 10, 1955, when he flew a Republic F-84F Thunderstreak from Los Angeles to New York in 3 hr 44 min 53 sec—later confirmed as a record by the National Aeronautic Association.

Maj. Glenn's aircraft (one of two Crusaders which set out, the other having to land at Albuquerque, New Mexico owing to in-flight refuelling difficulties) was refuelled three times during the flight, which was carried out mainly at 35,000ft and at a top speed of "a little over 1,000 m.p.h."

Rockets and Satellites

LAST week's three-day symposium on high-altitude and satellite rockets, held jointly by the Royal Aeronautical Society, the British Interplanetary Society and the College of Aeronautics at Cranfield, attracted some 150 specialists, from nine countries, interested in various aspects of the field. Ten papers were presented, and an exhibition, to which the public was admitted, was held concurrently with the symposium.

Among the contributions which attracted wide interest were a description by Mr. W. H. Stephens (R.A.E., Farnborough) of the Skylark rocket sponsored by the I.G.Y. Gassiot Committee and designed and developed by the R.A.E.; details, given by Mr. Milton Rosen (U.S. Naval Research Laboratory) of the three-stage vehicles constructed to lift the 20in, 20 lb Vanguard satellities into their orbits; and opinions on future developments in propulsion, by Dr. R. L. Shepherd (A.E.R.E., Harwell). Prof. Boris Petrov, of the U.S.S.R. Academy of Sciences, described the Russian I.G.Y. programme, saying that both sounding rockets and satellite vehicles would be used. The rockets would be fired from two zones in the U.S.S.R. and from Antarctica, to a total number of 125 during 1957-58; and the satellites would be launched at a small angle to the meridian so that in due course they would pass over the entire surface of the Earth, except for the central polar regions.

Papers dealing with the various aspects of the problem of bringing vehicles back to the Earth's surface also caused considerable interest, Dr. W. G. Hilton (Armstrong Whitworth Aircraft) speaking of gliders which, with high induced drag and negative lift, would fly "upside-down" with respect to the surface and skip in and out of the atmosphere.

We hope to publish summaries of a number of the papers, and notes on the exhibition, in next week's issue.

In Australia, the Department of Supply is currently holding an I.G.Y. exhibition, and among the exhibits is Skylark, the 100-mile rocket, and the HARP rockoon. The latter, which is to be lifted to about nine miles by a 12,000 cu ft plastic balloon and fired by remote control to reach about 60 miles, has a body made of glass-reinforced plastic by the special projects division of the Australian Fairey Company.

Helicopter Association Presidency

THE Helicopter Association announces the election of Col. J. W. Richardson as chairman in succession to Dr. G. S. Hislop, who now becomes vice-chairman. Dr. H. Roberts succeeds Col. Richardson as hon. secretary.

Flying Training Command Entertains

GARDEN PARTIES, aeronautical and otherwise, are still very much a part of the traditional English scene—and still at the mercy of traditional English weather. When the A.O.C-in-C. and officers of Flying Training Command H.Q. gave their annual garden party at Shinfield Park, near Reading, last Saturday, the day was beset by terrific and frequent rainstorms; but fortunately a clear patch not only made the function possible but also allowed Air Marshal Sir Richard Atcherley to receive his guests on the lawn; it even permitted the customary cricket and tennis matches.

A new feature of the party this year was the beating of the retreat by the apprentices' pipe band (commanded by W/O. F. E. W. Bailey) from No. 1 School of Technical Training, Halton.

Aerobatics at Croydon

BRILLIANCE in aerobatics was demonstrated by the Czechoslovak team at Croydon on Sunday, July 14, following their success at the Baginton meeting on the previous two days. The occasion was an At Home organized by the Surrey Flying Club and the Association of British Aero Clubs, and the stars of the day were undoubtedly Vilem Krysta, Miloslav Prikryl and Karel Krenc in their trim Zlin Akrobats.

In between the rain-showers, the air traffic controllers in Croydon tower looked down on the bellies of each of the Akrobats in turn as, inverted, the agile Czechs cavorted past the terminal building. Outside loops, outside turns and outside circuits were included in a sparkling performance. Each pilot was superb. Individual demonstrations by each of the three were followed by a double-act by Prikryl and Krenc, ending in an exhilarating aerobatic tailchase. The Czechoslovak contribution also included a stylish display by Jiri Blaha in the Super Aero.

The afternoon's programme contained items by the Tiger Club; C. A. Nepean Bishop and P. Langstone (solo Tiger aerobatics); the Airways Aero Club (Chipmunk formation display); Surrey Flying Club; an E.P.9 flown by Edgar Percival, and a four-seat Jackaroo flown by Lt-Cdr. C. P. Shea-Simonds.

FROM ALL QUARTERS . . .

The Gliding Championships

THIS year's National Gliding Championships at Lasham airfield, Hampshire, will begin with a practice day tomorrow (Saturday, July 27), which will include an air display and an aerobatic competition. The championships will be officially opened by the Duke of Edinburgh at 10 a.m. on Sunday, July 28, and will continue until Monday, August 5.

As mentioned in last week's special gliding section of *Flight*, there will be two separate leagues in the contest. As we go to press there are 29 entries in League 1 and 43 in League 2. Among the aircraft are nine Slingsby Skylark 3s, three Eagle two-seaters, a Schweizer 1-26A and the Short Nimbus two-seater.

Entrance to the championships for the general public will cost 2s 6d (children 1s, car park 2s 6d, motor-cycles 1s). From London, the main routes to Lasham are (a) through Guildford, Farnham and Alton, turning right from A.31 on to A.32 and left at the Golden Pot; and (b) through Egham, Camberley, Hartley Wintney and Odiham.

Bradford Celebrations

WELL known in the motor and aircraft industries as manufacturers of pistons and associated components, the Bradford firm of Hepworth and Grandage, Ltd., is this year celebrating its golden jubilee.

Among events of the celebration was the opening, last week, of a new office building and warehouse opposite the present factory, the ceremony being performed by racing motorist Stirling Moss, assisted by the company's chairman and joint managing director, Mr. G. C. Hepworth. In the new extensions—erected on the 8½-acre site of a former cinder-tip—a large degree of automation will assist in the handling of an increasingly large flow of the firm's products.

The opening ceremony was attended by a number of famous exponents of speed on the road and in the air, the latter including A. W. ("Bill") Bedford, Hawker chief test pilot, and racing pilot Fred Dunkerley.

At a luncheon after the ceremony, attended by nearly 400 guests, Mr. J. L. Hepworth (joint managing director) spoke of the company's progress since 1907, and Ald. Harry Weston, J.P., a former Lord Mayor of Coventry, replied.

The Bradford firm have more than kept pace with changes in aero-engine design; since 1951 a subsidiary company, Hepworth and Grandage (Yeadon), Ltd., has been in large-scale production with turbine blades. For these, as with pistons, the old-established trade-name "Hepolite" is retained.

APPOINTED to the Board of the Hawker Siddeley Group are Mr. H. G. Herrington (left) and Mr. G. C. R. Eley. Further details, page 145.

Cranfield Presentation Day

COMPLETION of the tenth two-year post-graduate course at the College of Aeronautics, Cranfield, was marked by the presentation of diplomas and prizes at the College on Friday, July 5. The presentation was performed by Mr. A. A. Part of the Ministry of Education, deputizing for Sir Gilbert Fleming, Permanent Secretary to the Ministry.

Diplomas were awarded to the following students, whose names are grouped according to specializations:—

Aerodynamics: K. W. Bateman, J. W. Bugler, G. F. Churchill, M. A. Coote, G. G. Hall, N. C. Hanslip, M. J. Hawker, E. R. Kendall, E. Kisielowski, D. J. Marsden, D. J. McNally, T. P. S. Opatowski, G. Radhakrishnan, J. L. Robinson, R. W. Simpson, D. J. Stewart; *Aircraft Design:* P. J. Armitage, A. J. Bamford, S. Barrett, J. A. Boddy, C. D. Coxhead, G. A. O. Davies, D. Iredale, E. E. S. Jones, A. Lawson, C. S. Naik, D. H. Pepper, P. R. Reed, J. Robinson, J. W. C. Sandford, D. H. Smith, B. J. Summers, M. A. Wallis, P. Westmoreland; *Aircraft Economics and Production:* C. C. Brake, R. E. Catterwell, E. M. Cowburn, J. K. Foden, J. A. Leitch, R. C. G. T. Rogers, J. M. Smith, P. R. Smithers, H. E. Tuisku; *Aircraft Electrical Engineering:* P. Albuquerque, R. I. Gray, A. F. V. Leat, V. S. Narayanan, J. E. Toplis; *Aircraft Propulsion:* P. N. Cockshott, B. H. Croft, G. W. Ellis, J. R. Hatfield, W. F. Hayes, E. R. Norster, J. R. Romanow; D. M. Squires, P. Susilvorn. A certificate for the one-year advanced course was awarded to A. O. M. Vialls (Aircraft Propulsion).

Special prizes were presented as follows: R. I. Gray, Governors' Prize; E. M. Cowburn, Principal's Prize; E. R. Kendall and G. Radhakrishnan, Woods of Colchester Prize in Aerodynamics; R. I. Gray, Woods of Colchester Prize in Aircraft Electrical Engineering; G. A. O. Davies, S.B.A.C. Prize in Aircraft Design; P. R. Smithers, S.B.A.C. Prize in Aircraft Economics and Production; J. R. Hatfield, S.B.A.C. Prize in Aircraft Propulsion, and Royal Aeronautical Society Prize for 1956.

P.1 POSTSCRIPT

WITHIN the restricting limits of security classification, additional information was forthcoming last week from English Electric about the P.1, including an announcement that "a prototype [the P.1B] has flown at speeds in excess of the existing world speed record". It was not intended to imply that a P.1 would attempt to recapture the record in the near future (Fairey have also flown the F.D.2 faster than the timed speed); or indeed anything except to use 1,132 m.p.h. as a reference to the P.1's potential performance where more exact information could not be given. Design speed is higher than this, and the Mach number attained by the F.D.2 in establishing the record (M=1.73) had been passed by the P.1 in a slight climb and still accelerating.

Four prototypes (three P.1As and one P.1B) have been built, and these will be followed by two further P.1B prototypes and by 20 pre-production aircraft to develop the production standard. One P.1A has been used for ground mechanical test and another is now flying (as we described in our issue of April 26, 1957) with a modified leading edge near-conically cambered and cranked to increase the tip chord and to reduce the t/c ratio outboard of the vortex-control slots. These slots have been reduced in width since the aircraft first appeared and can be seen to shroud the intake to an open pipe—possibly the fuel-tank vents.

An interesting control detail is that the adjacent trailing edges of the aileron and flaps are thickened locally with glass-fibre inserts in order to reduce the chordwise included taper angle below 10 deg; this has been established as the empirical maximum if flow break-away over the control surfaces at transonic speeds is to be avoided.

Aerodynamic troubles with the P.1 have been remarkably few, thanks largely to the extensive use that has been made of the wind-tunnel facilities available at Warton. These include a 9ft by 7ft slow-speed tunnel (operated almost entirely by girls) and an 18in-square-section high-speed tunnel in which the flow is induced by two Nenes. This tunnel runs at Mach numbers of 0.5 to 1.1, and section chokes can be fitted to raise the operating Mach number up to 1.8. Heat from the Nene exhausts is used to raise the temperature of the induced-flow air and thus reduce condensation in the working section. A start has also been made at Warton upon a 4ft-square-section blow-through tunnel having an operating Mach number range of M=0.4 to M=4.0, and also on another tunnel which will operate at about M=6.0. These will be used for both missile and aircraft development.

Relocation of the speed brakes between the P.1A and P.1B have been made as a result of careful tunnel testing. The position originally chosen on the rear fuselage sides ahead of the jet nozzles was chosen to avoid a pitching moment when the brakes were extended, but caused some buffeting from interference with the tailplane. It seems unlikely that all airflow interference can have been avoided in the position adopted forward and above the tailplane of the P.1B, but interaction between wing, airbrakes and tailplane could result in a neutral overall effect.

During a recent demonstration of the P.1A at Warton, it was noticed that the spring-loaded auxiliary intake doors—which relieve negative pressures during ground running—remained open during position-error test runs at speeds of up to about 200 kt. On low-speed runs, incidentally, it was noticeable that W/C. Beamont was able to make turns of not more than 1,000 yards' radius—i.e., comfortably within the airfield boundary. The braking parachute which was streamed on landing is housed in an enclosed bay forward of the tail bumper, which also acts as a fairlead for the parachute cables. The anchorage is on top of the fuselage aft of the rudder, and the cables are neatly stowed in lipped grooves on the trailing edges of the fuselage skin around the jet-pipe nozzles.

Afterwards, W/C. Beamont, commenting upon the P.1's ability to pull very high g without running into control difficulties, said that he had "never before flown a fighter which gives the pilot so many of the qualities wanted in a fighting aeroplane . . . it is straightforward and simple, with no vices." Transition from the Hunter to the P.1 should be accomplished without difficulty.

[*The P.1 flight-test programme was the subject of an exclusive feature article in our last week's issue.*]

ROLLS-ROYCE

GAS TURBINES

for

short, medium

and long range

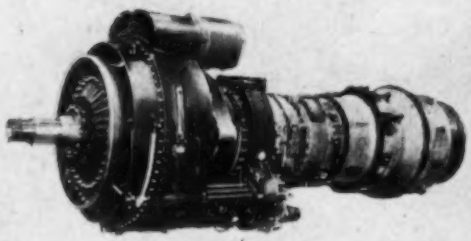
airliners

Rolls-Royce have over 2,500,000 hours experience in the operation of gas turbine engines in scheduled airline service.

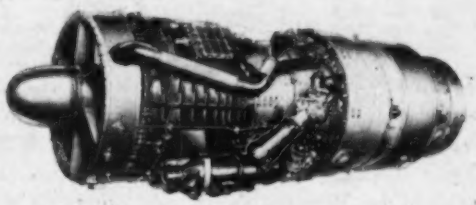
ROLLS-ROYCE LIMITED
ENGLAND · SCOTLAND · CANADA · AUSTRALIA

DART
PROP-JET
Vickers Viscount · Fokker F-27 Friendship
Aviation Traders Accountant
Armstrong Whitworth 650
Handley Page Herald

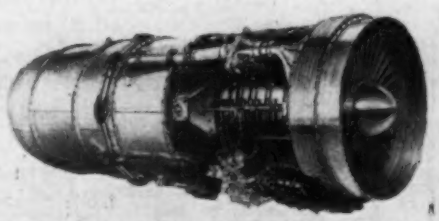
TYNE
PROP-JET
Vickers Vanguard
Armstrong Whitworth 651



AVON
TURBO JET
de Havilland Comet
Sud-Aviation Caravelle

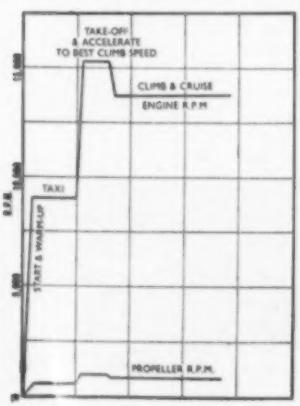


CONWAY
BY-PASS TURBO JET
Boeing 707 · Douglas DC-8
Vickers VC 10



Yes, with the VANGUARD

The many problems of noise nuisance on and around airfields will be reduced by the introduction of the Vickers Vanguard. Noise from the four Rolls-Royce Tyne propeller-turbines is remarkably low for an aircraft of the Vanguard's size and power. This will be of particular advantage when operating from airfields in or near residential areas. A lower noise level on the airport will also increase efficiency in the administrative blocks and improve the broadcasting of passenger information. The lower interior noise and vibration will win approval from operators, pilots and passengers.



For your notebook...

Gases from the Tyne engines are only exhausted after the power has been absorbed by the turbine. This is one reason for reduced noise. The other is the low propeller tip speed.

VICKERS VANGUARD

FOUR ROLLS-ROYCE TYNE PROPELLER-TURBINE ENGINES

VICKERS-ARMSTRONGS (AIRCRAFT) LIMITED WEYBRIDGE SURREY

TGA AT541

Six-abreast spaciousness appears to be the most striking feature of the Antonov Ukraina 350 m.p.h. turboprop transport, soon to enter Aeroflot service. Cabin width and height compare with the DC-8 and 707. The aircraft seats 84 passengers.

CIVIL AVIATION

B.E.A.'s JET ORDER

THE chief executive of B.E.A., Mr. Anthony Milward, said at London Airport on July 19 that his Corporation would decide "within the next two weeks" on its pure jet re-equipment programme. He added: "We will be meeting representatives of some of the four aircraft firms who may be able to meet our requirements. The time is very close when we will have to make a decision." Delivery, he said, would be needed by the end of 1962.

Avro, Bristol and de Havilland are known to be offering short-haul jet transport projects to B.E.A.'s specification; the fourth firm mentioned by Mr. Milward is presumably Vickers-Armstrongs (Aircraft), Ltd., although it would be remarkable if this firm, with its new VC-10 commitments to B.O.A.C., were to embark on the different design for B.E.A.

STRONG WORDS IN THE HOUSE

A DEBATE in the Commons on Monday of this week concerned a financial formality (the £5,989,700 vote for the M.T.C.A.). In the event the Opposition used it as an opportunity for some angry, and in our view unjustified, criticism of the Minister for his policies concerning the Corporations and the private airlines.

The nub of the Opposition's argument was that the Minister had appointed as B.O.A.C.'s chairman someone with financial interests in the private airlines; and that the Minister had gone on to make depredations into B.O.A.C.'s future business by promising private enterprise a 30 per cent share of third-class traffic to Africa.

Mr. Harold Watkinson said that he had listened to the debate with "astonishment". His policy had been "a simple bit of elementary justice to allow the airlines concerned to keep the traffic which they had created".

PRESSING ON AT GATWICK

TO a muted accompaniment of bulldozers and runway-layers, Mr. Airey Neave, joint Parliamentary Secretary to the Ministry of Transport and Civil Aviation, last Monday visited Gatwick and gave the Press some details of progress there. Amidst the lumber of civil engineering on every hand, the airport is rapidly taking shape. On August 1—less than a week away—the London to Brighton road (the extension of which has been completed for some time) will be diverted under the new terminal building. The latter is substantially advanced, a skeletal runway and taxi track has been laid, and the control tower is largely complete.

It is claimed that Gatwick will be the first airport in the world to combine air, rail and road transport, and it seems likely that Gatwick will require no counterpart to the city terminals which serve other airports. The passenger building has been so designed that those arriving by train or by car remain under cover until they leave the central finger to board their aircraft. Another innovation adopted from the system in use at Paris-Orly is that for out-bound Customs inspection; luggage is collected and customed on arrival, but the passengers themselves do not come under Customs control and are not segregated from their friends until they are called to join the aircraft.

Asked what the total cost of Gatwick's development would be, Mr. Airey Neave quoted a new figure of £6.8m, including £420,000 for telecommunications, navigation aids and radar. This is for an airport with a single 7,000ft by 150ft runway; but an additional shorter runway sited roughly north to south, as well as further fingers from the terminal building, could be added if warranted by traffic growth.

Gatwick has been shown to be usable on 55 per cent of the occasions when London Airport is below minima and, as an alternate, will be able to accept Boeing 707s at their landing weight. B.E.A. are expected to use Gatwick for their Channel Islands and shorter Continental services soon after the airport is opened in April 1958, a date that—in spite of the enormous amount of work remaining to be completed—the contractors expect to achieve. Transair are so far the only independent operators to have started to build their new headquarters at Gatwick, although British Aviation Services are likely to follow suit. Others are clinging hopefully to Croydon.

A picture which adds weight to reports from India that the Fokker Friendship may be licence-built in that country. It shows Mr. Nehru examining the aircraft during his recent visit to Holland.

BOEING RELEASE 717 DETAILS

ALTHOUGH Boeing announced the medium-sized member of their 707 family, the 717, some months ago, fuller details have not been made public until now.

It appears that, although the 717 will be built on the 707 production line at Renton, and will have the majority of components in common with the 707, it will in fact be a very much lighter aeroplane. With a maximum take-off weight of "from 185,000 lb," the 717 falls into the medium-jet category. Fuel tankage, about 68,000 lb, is only a little more than half that of the domestic 707-120; range with maximum payload (32,500 lb, compared with 42,700 lb of the -120) is given as 1,700 miles. Passenger seating varies between 88 and 130—a large passenger capacity for this class of aeroplane. Engines are Pratt and Whitney JT3s.

Boeing claim that the 717 will operate economically over stages of between 200 and 1,700 miles, cruising at between 550 and 600 m.p.h. at altitudes of from 25,000ft to 40,000ft. This suggests that the 717 is being offered also as the answer to the airlines' short-haul jet requirements, and that Boeing's specialist short-haul project, the so-called 727, continues to be shelved.

"The 717," say Boeing, "is the third step in the Boeing plan to provide the airline industry with a complete family of modern airliners, one or more of which will provide the best possible economics for any particular airline route pattern, while retaining a very high degree of commonness. . . ."

Boeing 717: Span, 130ft 10in; length, 128ft 10in; height, 38ft 7in; cabin width, 12ft 4in; sweepback, 35 deg at 25 per cent chord; gross weight, 185,000 lb plus; design payload, 32,500 lb; fuel capacity, 10,092 U.S. gal.

K.L.M.'s LOSS

ON Monday, July 15, a Lockheed L.1049E Super Constellation of K.L.M., PH-LKT *Neutron*, crashed into the sea immediately after taking off from Biak, Dutch New Guinea. Of the 68 passengers and crew on board, 57—three of them British—lost their lives. Eleven people were rescued by Papuans in their native craft, including the stewardess, who was the only member of the crew to survive.

No likely cause has been suggested for the accident, which was the worst in K.L.M.'s history. The aircraft was operating the regular twice-weekly service between Biak and Amsterdam. The majority of the passengers killed were Dutch military personnel and government employees and their families.

Another picture from Boeing, Renton, showing the progress of the first two production 707s for PanAm. Delivery of the first fully certified aircraft is due to be made in December 1958.

Keeping in touch with B.O.A.C. operations at London Airport last week was Mr. Harold Watkinson, Minister of Transport and Civil Aviation. He is seen here in the captain's seat of a Britannia 102 talking with Captain W. B. Houston, the Corporation's training manager.

CIVIL AVIATION . . .

TWIN PIONEERING ACROSS THE WORLD

WE remarked recently that the Caravelle's 30,000-mile, 150-hour sales demonstration tour of North and South America was probably the most ambitious flight of its kind ever undertaken by a transport aeroplane. No one has disagreed with this statement—not even Scottish Aviation, whose Twin Pioneers G-AOEN and EP have this year completed between them world demonstration flights covering 46,000 miles and involving more than 500 flying hours. It is noteworthy that the Scottish Aviation flights were unsubsidized commercial undertakings.

The flights began in January last, when two Twin Pioneers set off from Prestwick, G-AOEN bound for North and South America and G-AOEP bound for the Middle and Far East and Australia.

The U.S. tour of G-AOEN was confined to giving demonstrations to military authorities, and the aircraft called at Washington, Winston Salem, Fort Rucker, and Miami. From there the aircraft flew *via* the Bahamas, Jamaica and the West Indies to visit all the countries of South America. The Andes were crossed three times, and full-load demonstrations were given at La Paz (13,404ft).

The eastbound aircraft, G-AOEP, flew to Australia and Tasmania, giving demonstrations *en route* in Italy, Iraq, Persia, Kuwait, Pakistan, India, Burma, Thailand, Cambodia, Indo-China, Malaya, Singapore, Sarawak, Brunei, British North Borneo, Philippines, Java, Bali and Timor.

Each Twin Pioneer had a crew of two pilots and two engineers, and carried spares for six months' operation. Both aircraft were fully serviceable at the end of their tours.

BREVITIES

TURKISH Airlines (DHY) are reported to be considering the purchase of an all-Dart fleet of Vickers Viscounts and Fokker Friendships.

* * *

Fairchild expect C.A.A. certification of the Fokker Friendship prototype in about five weeks' time.

* * *

Australian dealers are reported to be quoting up to £40,000 for used DC-3s. Two have just been bought by "a Nigerian airline".

* * *

All T.C.A's aircraft are to be given "white tops". The colour scheme will otherwise remain unchanged.

* * *

Lockheed say that they are "actively investigating" the market for a commercial version of the C-130 Hercules.

* * *

A new airport is being constructed for Belgrade at Surcin, about nine miles from the Yugoslav capital. The main runway will be about 7,000ft.

* * *

Aeroflot has announced plans to open a Tu-104 service to Copenhagen in October, this being dependent on the completion of runway extensions at Kastrup.

* * *

During the year ended June 30, and excluding car ferry traffic, Silver City transported 20,000 tons of cargo. This was a nine-fold increase on the previous year's cargo uplifted.

* * *

Independent Air Travel, Ltd., a British independent company formed last year, have added a DC-4 (ex-Eastern Airlines) to their fleet of eight Vikings. A second DC-4 is on option, and plans to acquire further DC-4s and some DC-6Bs are in hand.

* * *

It is reported that the Belgian delegation now negotiating with the U.S. State Department in Washington are seeking a route for Sabena from Montreal to San Francisco. They appear to have modified their request for a transcontinental service from New York, no doubt as a result of U.S. airline opposition.

* * *

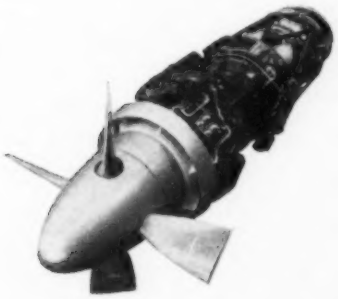
Howard Hughes, says the U.S. *Aviation Daily*, is negotiating the purchase of Britannias for T.W.A. He is still reported to be actively engaged in the purchase of Capital's 15 deferred Viscounts, plus a further seven, and he has also stated his interest in licence-production of the Caravelle for T.W.A. His order for Convair 880s still stands at 30 and for 707s at eight, though it is due to be increased to 26.

* * *

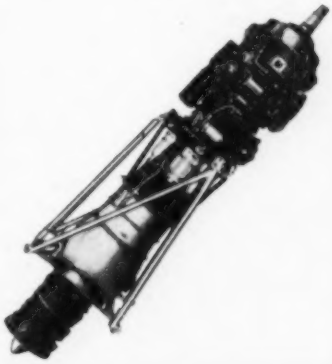
Matters being studied by the Institut du Transport Aerien, whose a.g.m. was held in Paris on July 9, include the outlook for air freight, traffic flows, speed-up of ground operations, air traffic control, and telecommunications. I.T.A., the international organization engaged in the study of air transport problems, now has 250 members in the operating and manufacturing industries.

* * *

An American Airlines DC-6 had to take violent evasive action near El Paso, Texas, on July 18 to avoid collision with "an Air Force jet, possibly a B-47". Two of the 85 people on board were slightly injured. According to the C.A.B., in a report published on July 17, there were 331 near-miss reports in the first three months of 1957. Of these, 95 per cent involved aircraft flying in controlled airspace.



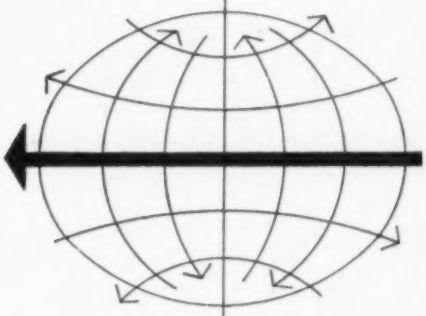
ELAND (for fixed wing aircraft) propeller-turbine engine for new airliners and conversion of piston engine airliners to propeller-turbine power. Chosen for the Hamburger Flugzeugbau C209 and the Convair 340.



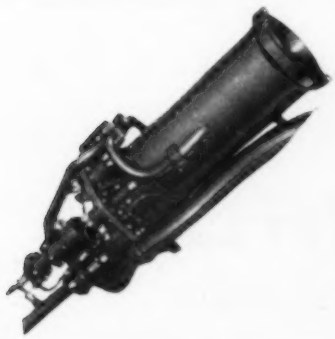
ELAND (for helicopters) specially designed for the Fairey Rotodyne, is basically the standard Eland with an auxiliary compressor mounted at the rear. A further design with a rear gear box is installed in the Westland Westminster helicopter.

ORYX turbo gas generator designed for helicopters where the rotor is propelled by jet reaction at the blade tips.

NAPIER AERO ENGINES



for the world



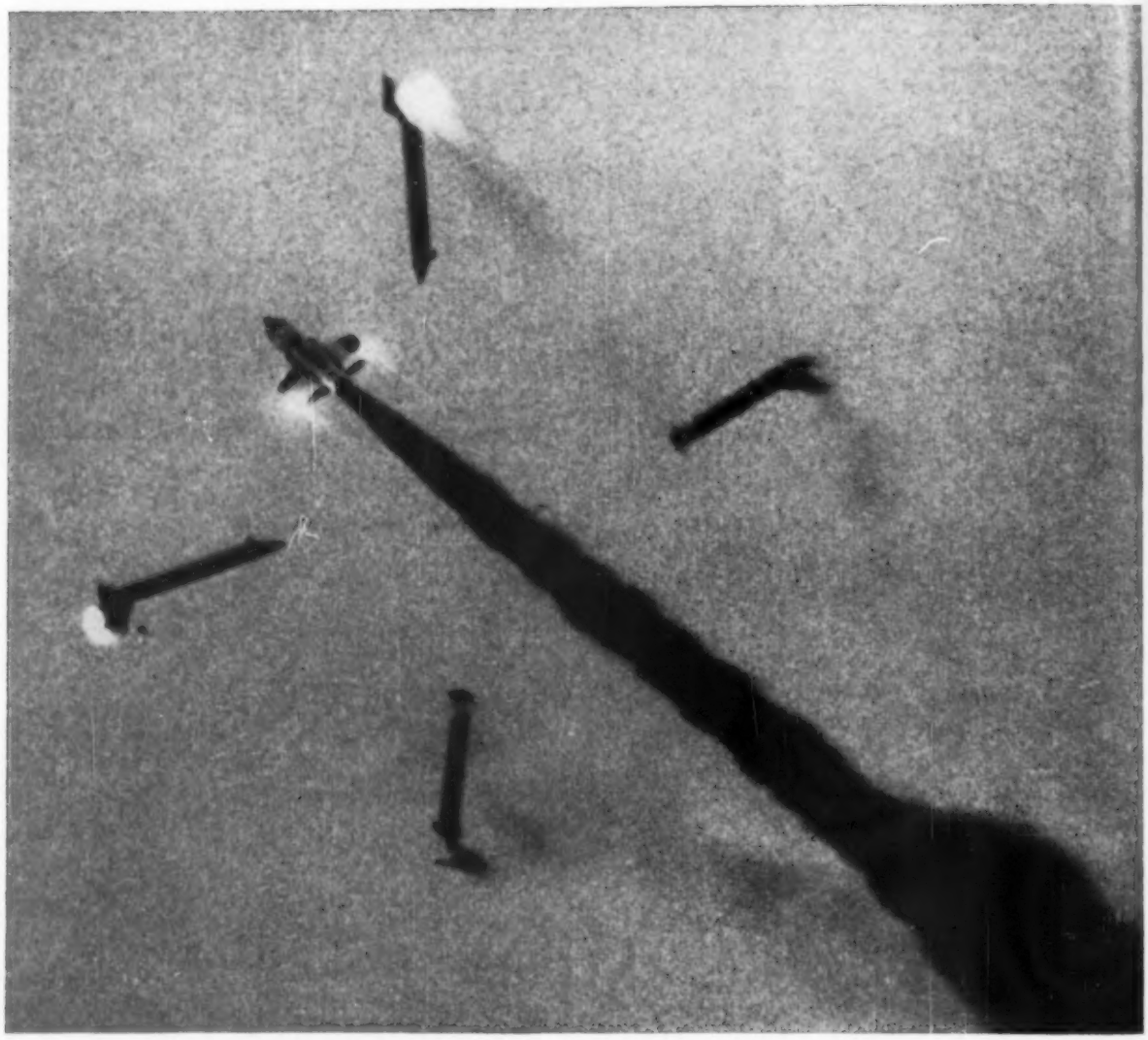
SCORPION an aircraft rocket engine which provides a source of extra power at high altitude. Designed for sustained firing and long operational life.

GAZELLE free turbine engine designed primarily for helicopter propulsion. Chosen for the Westland Wessex and the Bristol 192. Can be adapted for fixed-wing applications.

TIP THRUST UNITS for helicopters restore performance lost through heat, humidity and height. In operation in the Saunders Roe Skeeter.

D. NAPIER & SON LIMITED—LONDON, W.3. Member of the ENGLISH ELECTRIC Aviation Group

CBC 8.36



Crown Copyright reserved. Reproduced by permission of the Controller, H.M.S.O.

'ENGLISH ELECTRIC'

THUNDERBIRD

Now in production for either mobile or static air defence

'ENGLISH ELECTRIC' guided weapons THE ENGLISH ELECTRIC COMPANY LIMITED

Guided Weapons Division Luton · Stevenage · Woomera

A MEMBER OF THE ENGLISH ELECTRIC AVIATION GROUP

CIVIL AVIATION . . .

RUSSIA'S CONTENDERS

WE said something last week (page 93) of two new Russian transports which appeared at the Vnukovo airport (Moscow) air display on July 10. Here they are—the Ilyushin Il-18 Moskva (above) and the Tupolev Tu-110 (below).

The Russians appear to be wasting little time in re-equipping their national airline with the most modern aircraft: both these new types—which are larger partners for the Antonov Ukraina and the Tu-104—are scheduled to be in Aeroflot service before the end of this year.

The Russians never disclose much about their civil aircraft, which are always announced to the world with a clever awareness of the publicity value of surprise. These tactics tend to make the West regard Russia's aeroplanes as being more impressive than they in fact are: but while the Tu-110 appears to be a straightforward four-engine stretch of the Tu-104, the Il-18 Moskva (whose cabin the left-hand picture portrays) must be regarded as a very advanced, large-capacity medium-range turboprop, capable of cruising at 405 m.p.h. and falling directly into the Vanguard/Electra category. Mr. Ilyushin is in the centre of the group above; on the left is test pilot V. K. Kokkinaki, and (right) chief designer V. N. Bugayevsky.

Yet to appear is the Tupolev Rossiya, reputed to be a 180-passenger, 550-m.p.h., 4,300-mile-stage transport powered by four very powerful turboprops. It is due to fly in October, and is clearly Russia's rival for the DC-8 and 707. It will have comparable speed, capacity and range, but will be more than a year earlier and (it is claimed) will show superior economics.

HANDLING THE SUPER AERO

A Czechoslovak Light Twin for Import

By C. M. LAMBERT

THOUGH precious few foreign aircraft of the executive type can be imported into Britain, the Anglo-Czechoslovak trade agreement will allow a limited number of Super Aeros to be sold here. The price is quoted as £7,960 ex-works in Prague without radio, though customer's radio would be fitted free. Import duty of 17.5 per cent and ferrying charges must be added. Inspection and handling trials by the A.R.B. were to be completed last week for the granting of a British C. of A. Three machines may be imported this year and the manufacturers are quoting six to eight weeks' delivery time from receipt of order. The agents here are the Aircraft and General Finance Corporation, Ltd., 26/27 Poultry Chambers, 11 Poultry, London, E.C.2, and spares to the scale recommended by the manufacturers are to be stocked by Rollason Aircraft and Engines, Ltd., at Croydon Airport.

I cast a covetous eye on the Super Aero right from the start. Having flown it briefly at Venice last year (*Flight*, August 3, 1956) and been considerably impressed, I jumped at the chance of a longer flight—at Croydon last week—with Mr. Blaha, the Czech test pilot. Arrangements were made for colleague Alastair Pugh to fly photographer McLaren, who took the accompanying pictures. The cloud-base was rather low and rain was threatening, so I was not able to go through the full routine with the machine. Nevertheless, I sampled enough to confirm my earlier good impressions.

Comparison between British and foreign light executive aircraft tend to be unfortunate—for Britain—but I would make the following remarks, because *Flight* operates a Gipsy-Major-engined Gemini with Palmer hydraulic disc brakes, and gets a great deal of very useful service from it. Considering that some 400 of the Aero 45 series have been built, including about 100 of the Super Aero discussed here, the Gemini comes off well from comparison, even though it has had a more erratic development life. On two 145 h.p. engines the Gemini cruises at 140 m.p.h. very comfortably for something over 450 miles. With full fuel load of 66 Imp. gal it can carry (though barely) three passengers and a V.H.F. radio. Its slow-speed and short-field characteristics are particularly good; and with starters working off internal batteries, and with good brakes, it is entirely independent of external aid when operating from strange fields. This is a most valuable asset. Flap operation is mechanical and the electric undercarriage actuation has given virtually no trouble. A single-engined overshoot is quite straightforward and safe. The cabin is wide and high and very comfortable for long flights, though smoking is unwise, because the priming pump pushes a certain amount of raw fuel into the cabin. All in all, the Gemini is comfortable, useful and extremely simple.

The Super Aero has two 105 h.p. engines with electrically-variable-pitch metal propellers which can be feathered. Carrying four people and full fuel load of 71 gal it will cruise at 148 m.p.h. for 870 miles. At 62 m.p.h., its stalling speed is a good deal higher than that of the Gemini, but it has a maximum flap deflection of 55 deg, which produces a really steep glide. Because of their high drag, flaps must be raised immediately to gain height when overshooting. Both flaps and undercarriage are electrically operated. In fact, engine and blind-flying instruments, propeller controls and a number of other services are electric and have to be switched on individually, together with battery and the two generators. All this makes for a good deal of wiring, but the lower portion of the nose-cone can be hinged down to give direct access to the back of the instrument panel, the battery and electrical equipment. Four ashtrays are fitted.

With a maximum load factor of 3.8 or 4 the Super Aero is not really aerobatic, but demonstrations of two- and single-engined aerobatics with two and three occupants have been given very successfully. Blaha showed me an upward roll, from the deck up into a hole in cloud, which convinced me that, load factor or no load factor, the Super Aero can be gracefully and satisfyingly aerobatted.

The two major factors giving the Super Aero its very good performance are the v.p. propellers and its very clean design. In the latter respect cabin comfort has been slightly sacrificed, and it is rather too easy to bang one's head against the sloping canopy when sitting in the front seats. But there is plenty of soundproofing and the noise level is no higher than that of the Gemini. Exhaust muffs on both engines provide cabin heating and windscreen demisting. There is plenty of ventilation, particularly from a finely adjustable air scoop over each pilot's head. The long, sharply raked plastic windscreen structure gives excellent visibility on the ground and in the air, but is inclined to become obscured by rain, particularly when taxying. There is no clear-vision window.

Access is by raising the whole port-side transparent cover, and the baggage compartment is reached after dropping the back of the bench seat in the rear. The pilots' seats are individual and adjustable. Rudder pedals are not adjustable and the port set carries brake pedals for the hydraulic drum brakes on the main wheels. The tailwheel is steerable from the rudder bar and affords excellent control on the ground. General engine instrumentation and controls are approximately of Harvard standard, that is, they include manual fuel pumps and pressure gauges for use when starting; priming pumps; electric starters; mixture and power levers; three-position pitch levers with inching facilities for small pitch variations; adjustable engine-cooling flaps; carburetter heat controls; and fuel selectors with electric cross-feed for emergencies. Main fuel feed is by engine-driven pumps. The two fire-extinguishers cover the cylinder heads, carburetters and fuel pumps in each powerplant. Navigation, landing and cockpit lighting (including a separate light for the rear of the cabin) is standard.

The two inner fuel tanks, holding 19 gal each, have fuel gauges, while a red light shows when each of the 16 gal outer tanks is empty. All instruments and gauges are clearly marked with permissible operating ranges and danger levels, though some of the labels in this particular machine had rather quaint translations from the Czech. The A.S.I. carried a white line over the wheel and flap extension speed range, a red mark at the stalling speed, a green line over the normal cruising-speed range and a red mark at the V_{ne} point. This kind of thing is of incalculable help when operating an aircraft as an incidental adjunct to business, rather than as a specialized vehicle.

Apart from the tendency to bang my head on the side of the canopy and a slight obstruction of vision by the horizontal canopy strut, I found the Super Aero cabin very comfortable, and I particularly appreciated the "personalized" ventilation arrangements. Engine-handling and steering on the ground were outstandingly pleasant; and the throttle friction nut was the most precise I have ever encountered—a great help. The push-pull control wheel at first appeared a little niggardly, but turned out to be perfectly comfortable and effective, and to leave leg-room unobstructed. Noise levels were at all times reasonable and vibration was negligible.

Take-off was completely straightforward, with no appreciable swing and smooth transition from tailwheel steering to aero-

The Super Aero and (right) its cockpit, the instrument panel of which has plenty of unused cut-outs for extra items selected by the customer. Flying instruments and flap indicator are to port and engine and fuel indicators to starboard. On the horizontal strip below, magneto and undercarriage controls are on the left, propeller pitch controls next and the power and mixture quadrant in the centre. Below this and on the right are the many electrical system cut-off switches, amp/volt meter, starter buttons, pitot-heating switch and artificial horizon fast-erection push-button. On the floor between the pilots are fuel, extinguisher, priming, carburetter- and engine-heating and cabin heating controls, together with trim controls. "Flight" photographs

dynamic control. The tail came up quickly and easily and I flew the machine off when she seemed ready for it at something over 60 m.p.h. The flap switch and gauge, on the main panel bang in front of the pilot, are very good though flap response is fast and takes a little getting used to. The fairly stiff undercarriage switch is covered by a plastic dome (marked with maximum-extension speed) which has to be raised before operation. Red lights stay on all the time the wheels are not locked down, i.e., while they are moving or retracted; and green lights show locks engaged for landing. Mechanical indicators on the wings give additional indication of wheel position. Individual levers can be actuated to release compressed springs which will force each wheel down in case of electrical malfunction.

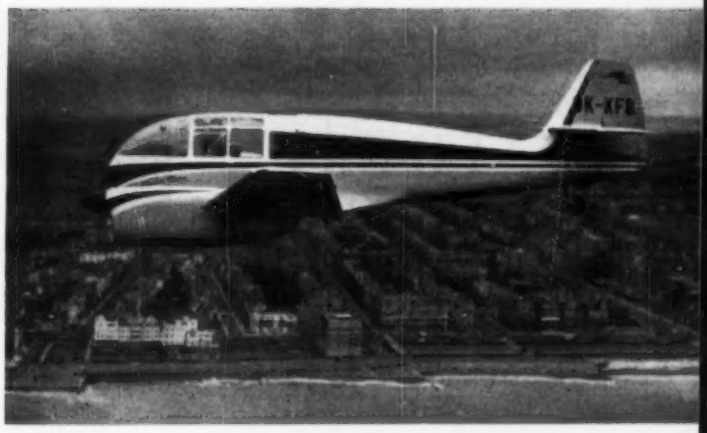
Initial climb at full load is a reasonable 750ft/min, achieved rapidly at about 95 m.p.h. after the aircraft is cleaned up. The climb-pitch setting is normally used for take-off, the setting marked "take-off" being reserved generally for short-field work. Care must be taken not to exceed r.p.m. limits when changing to finer pitch settings at high airspeeds. The climb is made at 2,500 r.p.m. Limiting r.p.m. are 2,600.

Settling into the cruise at about 800ft (just below cloud) I immediately felt the light and responsive ailerons. Lateral stability was neutral. The elevators were rather heavier, though not too much so. Fairly pronounced trim-changes occurred with variation in either speed or power. Torque effects were small and could be precisely taken out with the rudder trim wheel. By a weird oversight this wheel requires more than one turn from "lock to lock" but has absolutely no sure indication of trim-tab position! One finds the actual setting by experiment, since the rudder itself cannot be seen from the cockpit. Elevator trim is effective, but the lever provided for the adjustment is annoyingly spongy and could well be replaced by a wheel. (Blaha said this had been suggested to the manufacturers.) Settling down to a hands-off cruise takes a little time, but once the speed and power have stabilized and the trim has been fiddled into place, the Super Aero flies fast and steadily. For manœuvring, elevator trim is of great assistance in taking up moderate elevator stick forces. I felt that part of the difficulty (though this is by no means a major complaint) in adjusting for a hands-off cruise was due to a certain amount of friction in the elevator control circuit. Blaha agreed, but I would take into account the fact that this machine was brand new.

Available rate of roll is good and stability gives a very reassuring feel. One admirable characteristic is that, even with the trim set fully tail-heavy, a hands-off glide will rapidly stabilize at about 80 m.p.h. In case of an incipient stall the best drill is to release the wheel and the aircraft will immediately make for the 80 m.p.h. mark. With everything out and down, elevator trim is sufficient only to trim-out forces at this speed. At about 60 m.p.h. a fair rearward force is still required. Gliding in the approach configuration at 80 m.p.h., hands off, the Super Aero is steady as a rock and therefore the approach is simplicity itself. The maximum flap setting provides very marked drag and is recommended mainly for short fields and obstructed approaches. About 45 deg is a more normal setting. Engine control on the approach is excellent and the glide angle can be precisely controlled without difficulty. The flare-out, reducing power quite gradually, is exact and, though it is not too easy to put the tail right down for a three-pointer, the oleos are excellent and bouncing appears satisfyingly difficult. Full control on the ground is instantly available once the tailwheel is firmly down.

The Super Aero is a sleek machine and offers an excellent compromise between real performance and range and highly commendable economy. It nevertheless carries "grown-up" equipment without unnecessary complication. Full navigation and communications radio, both M.F. and V.H.F., has been installed in many of the Super Aeros sold in Switzerland. The machine in fact offers the performance (and equally important the intelligent design and good workmanship) of the smaller American light twins, but retains the "feel" of a pilot's aeroplane which distinguishes a European aircraft.

I imagine that the Czechoslovak Government is allowing the export of aircraft just as much for prestige as for financial gain; with this example they deserve both.



SUPER AERO

Two 105 h.p. Walter Minor 4-111 engines, with V-401E v.p. (electrically operated) airscrews

Dimensions: span, 40.46ft; length, 24.8ft; height, 7.73ft; wing area, 184.914 sq ft.

Weights: weight empty, equipment included, 2,112 lb; crew (4), 682 lb; baggage (in compartment), 132 lb, (in cabin) 66 lb; fuel (68.201 Imp gal), 492.8 lb; gross weight, 3,322 lb; wing loading, 18.1 lb/sq ft; power loading, 15.7 lb/b.h.p.

Performance: top speed (at 3,307 lb), 168 m.p.h.; cruising speed (at 2,300 r.p.m.), 146.17 m.p.h.; landing speed (55 deg flap), 62.2 m.p.h.; initial climb, 754.63ft/min; service ceiling, 16,614ft; s.l. take-off to 50ft (15 deg flap), 1,480ft; landing run from 50ft (brakes applied), 1,365.35ft; cruising (2,300 r.p.m.) fuel consumption, 10.67 Imp. gal/hr; cruise (149 m.p.h.) range with 60.201 Imp. gal, 6 hr or 871 miles; at 114.41 m.p.h., 8 hr 40 min or 1,088 miles.

"Flight" photographs

The photographs on this page emphasize the clean lines of the Aero 45, its distinctive canopy design, and the closely cowled engines. On the right, test pilot Blaha and C. M. Lambert take the aircraft along the South Coast westward from Brighton. The small picture above shows it in company with the "Flight" Gemini at Croydon.

HERE AND THERE

Malayan Air Force

PLANS to establish a Malayan Air Force after the country becomes independent on August 31 are expected to be completed shortly. A report from Kuala Lumpur says it will be brought into being "in co-operation with the R.A.F." and consist initially of training and reconnaissance aircraft and helicopters.

Culdrose at Home

TODAY (Friday, July 26) the R.N. Air Station at Culdrose is holding its Air Day, which will include a flying display supported by the S.B.A.C. The event is being held on Friday because that is the local early closing day.

Farewell and Hail

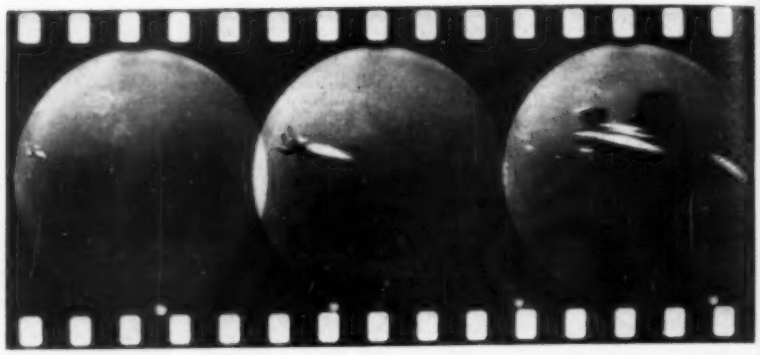
A FINAL parade of the Glider Pilot Regiment—raised in 1942 and now being disbanded—will be held at 3 p.m. tomorrow, Saturday, at Middle Wallop. The Regiment is being absorbed in the Army Air Corps, which comes into existence on September 1.

Bréguet Sahara

THE name Sahara has been conferred on the Bréguet 765—military version of the Provence (Deux Ponts) civil transport. Of the fifteen Saharas ordered by the French Air Force, the first will be delivered in June next year. Range will be nearly 2,500 miles.

U.S. Air Exercise

THIS week (July 22-27) the U.S. Tactical Air Command has been testing its ability to reach distant targets with atomic weapons by exercises covering South America, Puerto Rico and North Africa. A squadron of B-57s was responsible for the first part of the exercise; a flight of Super Sabres, refuelled *en route*, was to go to North Africa and B-66s were covering targets from the U.S.-Canadian border to Puerto Rico.



VICTIM'S EYE-VIEW of a Bristol/Ferranti Bloodhound, photographed by an automatic ciné camera on the wing of a target aircraft. Of two missiles fired, one hit and damaged the target, whilst the other missed by six feet. In either case, the proximity fuze of an armed missile would have detonated the warhead and destroyed the target.

Thor Guidance System

A CONTRACT worth $32m (£11m) has been awarded by the U.S.A.F. to General Motors Corporation for the construction of the guidance system for the intermediate-range surface-to-surface weapon Thor.

German Handover

ON July 18 the R.A.F. handed over control and ownership of Wahn Airport, near Bonn, to West Germany. It will now be used entirely as a civil airfield though a unit of the German Air Force is to be stationed there.

Orenda Appointment

THE appointment of Mr. David J. Caple as sales engineering manager of Orenda Engines, Ltd., Malton, Ontario, was recently announced. He was formerly administrative assistant to the vice-president, engineering.

Venoms from Egypt

IN Cairo recently the Egypt-Saudi Arabian Joint Command announced that the Egyptian Air Force had started delivery of fighter aircraft to Saudi Arabia under the two countries' military pact, and that these deliveries would continue until the end of August.

Norman Conquest

AWARDS for the first arrival at the Caen International Rally last week-end and for the best "traditional Norman costume" went to Francis Couesnon of South Kensington (Hornet Moth). At the Chateau de Creilly rallyists enjoyed a dinner menu chosen by the Caen gastronomical society (whose full title is translated as the Brotherhood of the Golden Tripedish). Tripe, bottles of calvados and muscadet, and various Norman cheeses accompanied the pilots on their return home.

High-energy Fuel

IN Niagara Falls, N.Y., recently the Olin Mathieson Chemical Co. announced the development of a new high-energy fuel—HEF-2—claimed to increase the range of jet aircraft by 40 per cent.

Jumping at St. Yan

THIRTY-TWO selected entrants will participate in the French national parachuting championships at St. Yan (August 18-25). They will comprise 17 amateurs, five civilian professionals chosen by the Service de la Formation Aéronautique et des Sports Aériens, and ten military parachutists.

More Sycamores for Germany

A FURTHER four of the 50 Bristol Sycamore helicopters on order for the West German armed forces took off from Bristol Aircraft's Weston division on July 15 on their delivery flight to the G.A.F. training schools at Fassberg and Memingen. The first two were delivered on May 31.

High Weight

AN announcement by the U.S.A.F. Air Research and Development Command said that at New Brighton, Minn, on June 28 a balloon with a diameter of 200ft and a volume of 3,750,000 cu ft lifted nearly two tons of equipment to an altitude of over 104,000ft. The test was a preliminary to an attempt to fire a large upper-atmosphere research rocket from a similar balloon.

BAGINTON ECHOES: An assortment of scenes from the National Air Races meeting (reported last week): Left, Nat Somers' Chipmunk, after a successful forced landing near Market Harborough following sudden conversion into a glider. Below, the No. 738 Sqn. Sea Hawks in the display; Biancotto of France, second in the Lockheed Aerobatic Contest in a Stampe SR-7, and Aresti of Spain (Jungmeister, sixth).

ARMSTRONG SIDDELEY

Development

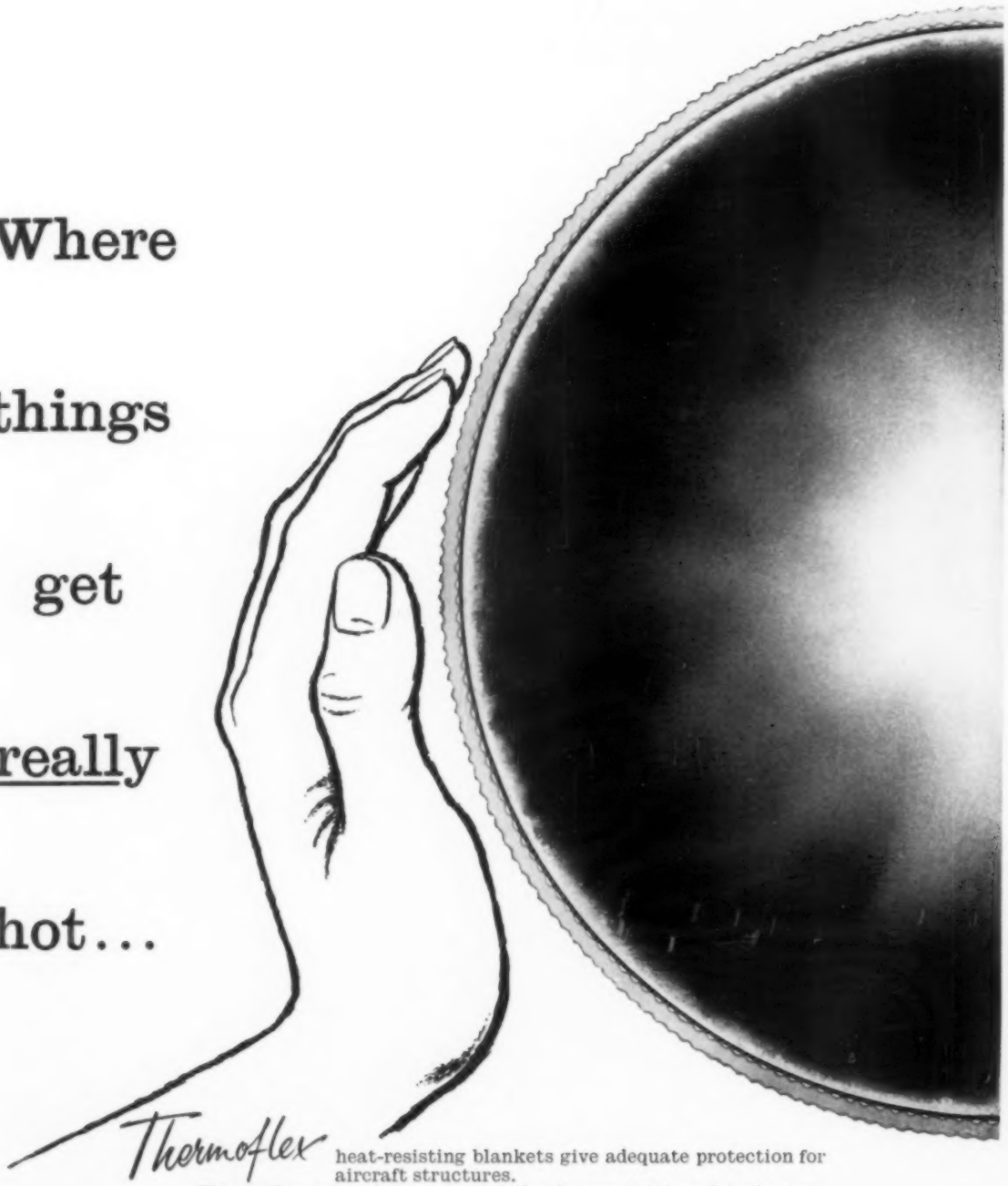
The continued development of the Sapphire series of engines underlines the genius of its original conception. First type-tested at 7,220 lb. thrust the Sapphire's power output has been consistently stepped up to meet the demands of many of the most powerful aircraft in the world. To-day the official type-test figure is 11,000 lb. thrust—an achievement the more remarkable because it has been effected without substantially altering the weight or size of the engine.

ARMSTRONG SIDDELEY
AERO ENGINES

COVENTRY AND BROCKWORTH
Members of the Hawker Siddeley Group

CAREERS *Many fine opportunities exist at ARMSTRONG SIDDELEY MOTORS*
Write to: Technical Personnel Manager

Where things get really hot...



Thermoflex heat-resisting blankets give adequate protection for aircraft structures.

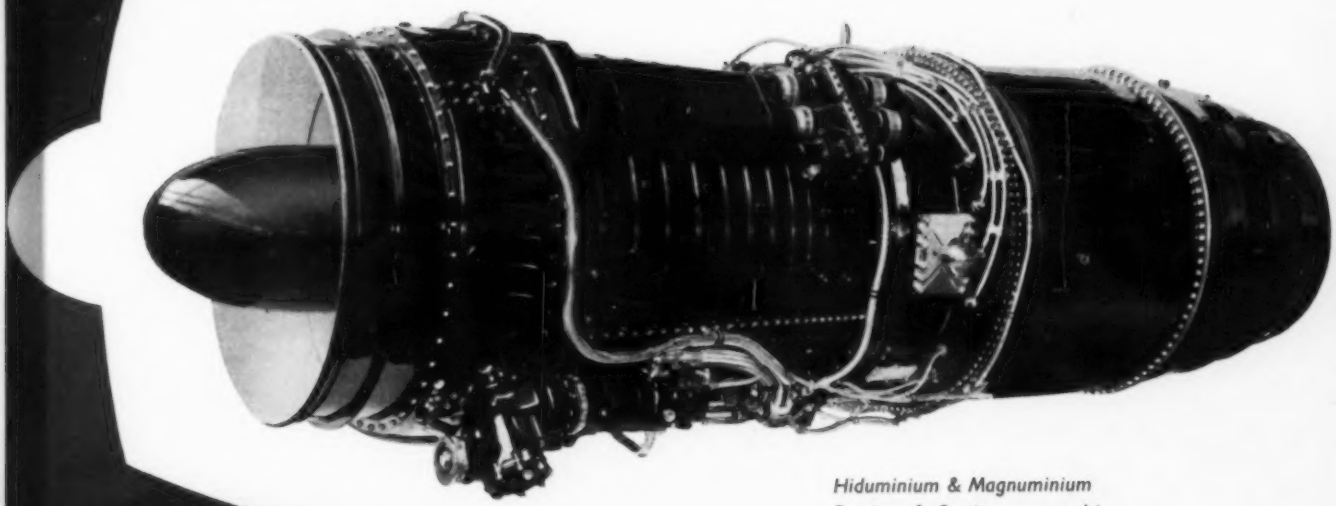
Thermoflex is used on many of the foremost jet and turbo-prop engines, and in certain circumstances can contribute a significant increase in critical performance. Its stainless steel inner and outer skins, with a filling of RF 300 refractory fibre insulating felt, offer a high degree of protection for a strikingly low weight. Thermoflex, a triumph of research and production, can be fabricated to complex shapes, the dimpled construction having due regard for the risks of abrasion or accidental denting.

We shall be glad to supply on request full technical data, and to discuss any special design problems.

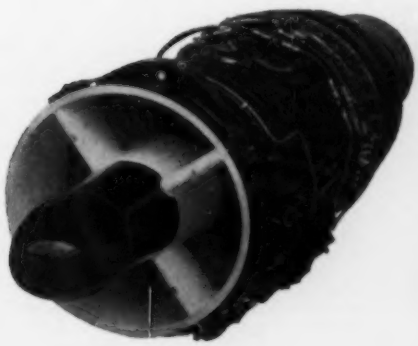
DELANEY GALLAY LTD

Vulcan Works, Edgware Road, London N W 2 *Telephone: GLAdstone 2201*

In every British Aero Engine



Hiduminium & Magnuminium Forgings & Castings are used in Armstrong Siddeley Sapphire Engines



Hiduminium

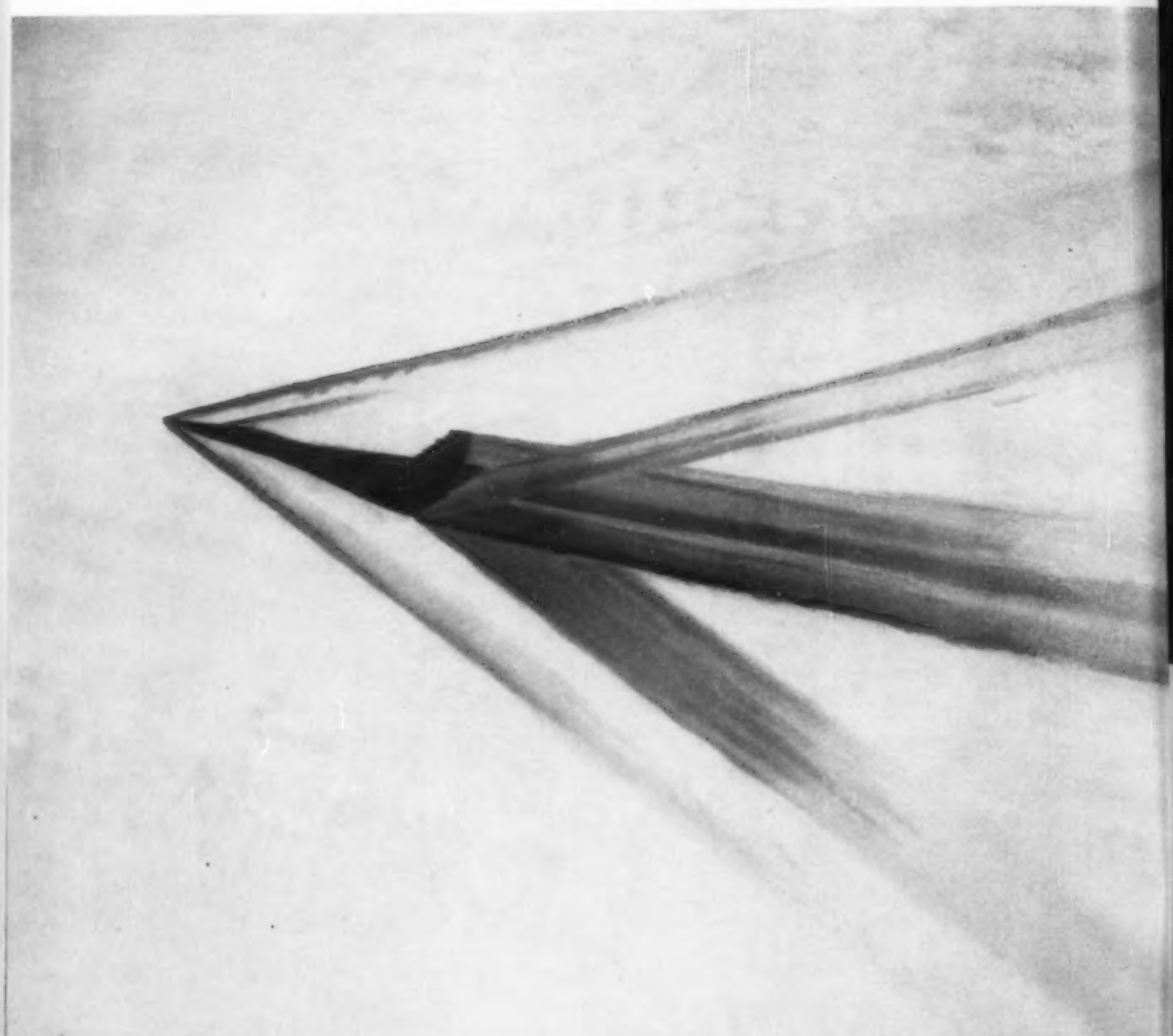
makes the most of

Aluminium

HIGH DUTY ALLOYS LTD

SLOUGH · BUCKS

DE HAVILLAND ENGINE RESEARCH SPEEDS THE WAY AHEAD



A series of paintings by W. Howard Jarvis, S.Av.A., illustrating aerodynamic shock-waves.

M=2·4

No. 4

A climbing flight path at M=2.4. The angle of the bow-waves and of the shock-wedge pattern on the wings increases in direct proportion to the aircraft's velocity. It is given by the simple trigonometrical function $\frac{\alpha}{2}=\sin^{-1}\frac{V}{va}$ where α is the angle between the shock-waves, V is the velocity of the aircraft and va the local speed of sound.

DH ENGINES

GYRON GYRON JUNIOR SPECTRE

The Marquardt supersonic ramjets are being developed with the aid of the Lockheed X-7 vehicle, here being launched from a Boeing B-29.

AERO ENGINES 1967

RANDOM THOUGHTS ON FUTURE PROPULSION

THE title contains no misprint; the essay which follows is presented as an onlooker's views upon the types of engines which we may expect to see ten years hence. "Fools rush in . . ." goes the saying. There are not many angels in the aero-engine business, but most of the engineers who are in it fear (and very wisely) to tread a path which leads much beyond what they can themselves see and touch.

This, however, is not the handicap which it sounds, since the engine designer of today does not have to stray into realms of fantasy in order to impress an observer—that is, provided the observer is "security cleared." The majority of people in aviation probably consider such engines as the Avon, Sapphire and Olympus as epitomizing all that is modern in aircraft propulsion. Modern, however, is a relative term; these engines were running in 1950 or earlier, and each was a gleam in the eye of a British designer well before VJ-day.

What ideas are producing gleams in the eyes of designers today?

Turbojets may well be discussed first. Such powerplants are already providing propulsion for well over 90 per cent of the world's combat aircraft, and will very soon begin a long climb to pre-eminence in the commercial field. Turbojets already built have flown to a Mach number of 2.3 and a height (with the engine still functioning properly) of 76,000ft. Airframes are being constructed which, with engines already in existence, will substantially improve on both figures. Since the gas turbine became available the aircraft designer has often found himself unable to make proper use of the power at his disposal. In this country we have an outstanding supersonic turbojet—and we almost had another—for which we have been unable to find any application at all. This, however, could lead the discussion into the realms of politics and the formulation of operational requirements, and the further one stays from this aspect of the subject the better.

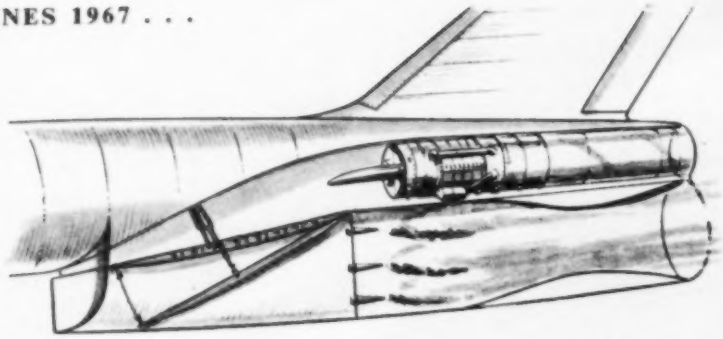
For the time being, at least, turbojets actually in service will have to run on kerosine or something closely akin to it. Changing over to an entirely new fuel poses logistic problems which are so far-reaching that even a nation like the U.S.A. could scarcely hope to accomplish the switch in under five years.

New fuels are not required in order to increase the thrust of a turbojet. More power can always be obtained by raising the turbine-entry temperature (provided the engine will stand it) and, as a photograph on page 109 dramatically shows, one can raise this temperature quite effectively merely by pumping in kerosine at a higher rate. The trouble is that competitive airframes cannot carry all the kerosine that is required to suit the dictates of the operational missions which are today necessary. The new fuels, on the other hand, pack appreciably greater heat-content into either a given weight or a given bulk, and thus more energy in British Thermal Units can be extracted from a given amount of tankage.

Most of the high-energy fuels—which are also dubbed "zip fuels"—were discussed in our issue of March 15 last. Generally they are liquids which, until recently, were available in laboratory quantities only. Now preparations are in hand in America, and possibly elsewhere, for the delivery of selected zip fuels at the rate of many tons daily to meet a requirement which may rise as high as 100,000 tons a day in the U.S.A. alone.

Two large chemical firms, Olin Mathieson and Callery Chemical Co., are both in the process of establishing extensive plants for the production of fuels based on compounds of boron. Each company has evolved for production purposes two types of

AERO ENGINES 1967 . . .



This completely hypothetical sketch suggests a possible configuration for a dual-cycle powerplant, of the type under development by Wright. A large flap-valve admits air to either a turbojet or a ramjet, the latter being employed only at supersonic speed.

fuel, one based on pentaborane and the other on decaborane. The former has a high heat-content per unit weight, and is therefore attractive in stretching the range of an aeroplane like the B-52; the latter is a dense fuel with a high heat-release for a given volume, and so it could well enhance the range of a machine like the P.1 or F-104, where the tankage is space-limited.

In the past boron-based fuels have been very difficult to handle, and quite impracticable as logistic materials capable of serving an air force in the field. Today they are relatively safe and non-poisonous, but they are still extremely abrasive and do no good at all to the blades of a gas turbine. It has been suggested that, perhaps by providing a special additive in the fuel, it would be possible to run-in an engine at a relatively low temperature while allowing a hard, glazed coating to build up on the turbine blades. Clearance would thereafter be granted for operation at extreme temperature and high gas-velocity without fear of erosion. Whatever course is adopted, it is extremely doubtful that blade-life could be made comparable to what can already be achieved using hydrocarbon fuels.

The zip-fuel engine itself would probably not differ greatly from an advanced supersonic unit of today (such as the hypothetical design illustrated on pages 562 and 563 of *Flight* for May 11 last year). Possibly the only superficially evident change will be a slight decrease in the length of the combustion system, since—with care—the new fuels can be made to burn at a very high rate. It would seem probable, however, that the first generation of zip-fuel engines will also have to be capable of running on kerosine, and so this advantage will have to be forgone.

In this connection, it is worth noting that it is apparently possible to accelerate the combustion of liquid fuel by subjecting it to bombardment from radioactive substances. In a report recently submitted to the American Chemical Society, the University of Michigan gave details of preliminary experiments in which beta-particles from radioactive gold were allowed to permeate hydrocarbon fuels; it was found that they "caused certain parts of the fuel to become more active chemically and to burn faster." As it would presumably be required only in small quantities, radioactive gold should present no insuperable logistic problem, although, of course, care must be taken in its storage and handling. It has not yet been revealed whether the fuel is to be exposed to the radioactive bombardment during a protracted period or whether the desired change can be accomplished by inserting a coil of radioactive gold around the feed-pipe to the engine (which the fuel may traverse at a fairly high velocity). It is likely that the acceleration of the reactivity of the fuel remains for a considerable period after the bombardment ceases, but the University of Michigan has apparently not confirmed this point.

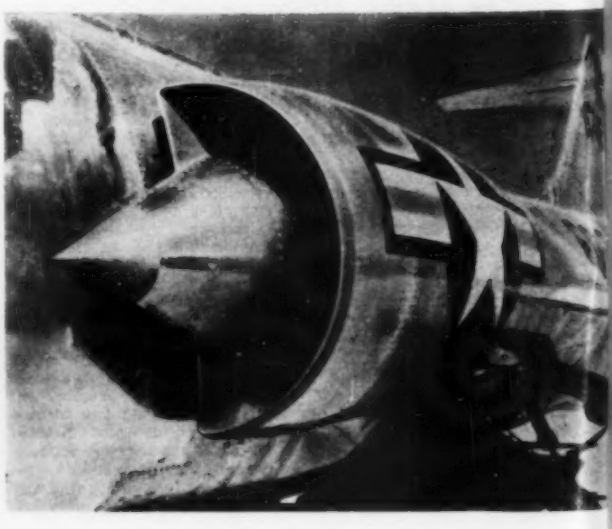
Most of the new fuels are swallowed much more readily by a ramjet than by a turbojet. Up to the present time ramjets have developed relatively slowly—largely, perhaps, owing to the ability of either the turbojet or the rocket (or both together) to fulfil most of the required propulsive tasks. Admittedly small subsonic ramjets have been used to power drones and helicopter rotors, but in general the ramjet only starts to make real sense at Mach 3 or above. Missiles already fly at such speeds, and it is noteworthy that the long-range anti-aircraft weapons chosen to defend America and Britain—Bomarc and Bloodhound—are each driven by twin ramjets after initial boost-propulsion by rocket.

As far as is known both weapons run on kerosine, but when high-energy fuels are introduced these seem to be ideal applications for them and the decaborane-based fluid would be particularly attractive in view of the space-limited tank capacity of all missiles. The erosive properties of all the new fuels should present few problems since there is nothing behind the ramjet fuel-burners but a large pipe and propelling nozzle. It should in any case be possible to provide film-cooling in the combustion chamber to keep the hot, erosive gas away from the metal wall.

There is, of course, no reason why ramjets should not power piloted aircraft. At maximum forward speed several modern afterburning fighter turbojets develop more than half their thrust as a ramjet. It could be argued that such engines are merely ramjets in which the compressor/turbine assembly is inserted in order to confer self-starting ability and to provide propulsion at relatively low speeds. It is appropriate to reflect upon the conditions under which such engines operate. As the sharp-edged intake—the picture (below) of the F-104 intake is typical of what has already reached the "hardware" stage—cuts through the atmosphere, the latter is rammed in until the air inside the engine becomes exceedingly hot and highly pressurized. In fact, when stressing a gas turbine to work at Mach 3 a designer has to face the problem of keeping the weight down while making the compressor-casing strong enough not to burst under the tremendous ram-pressure.

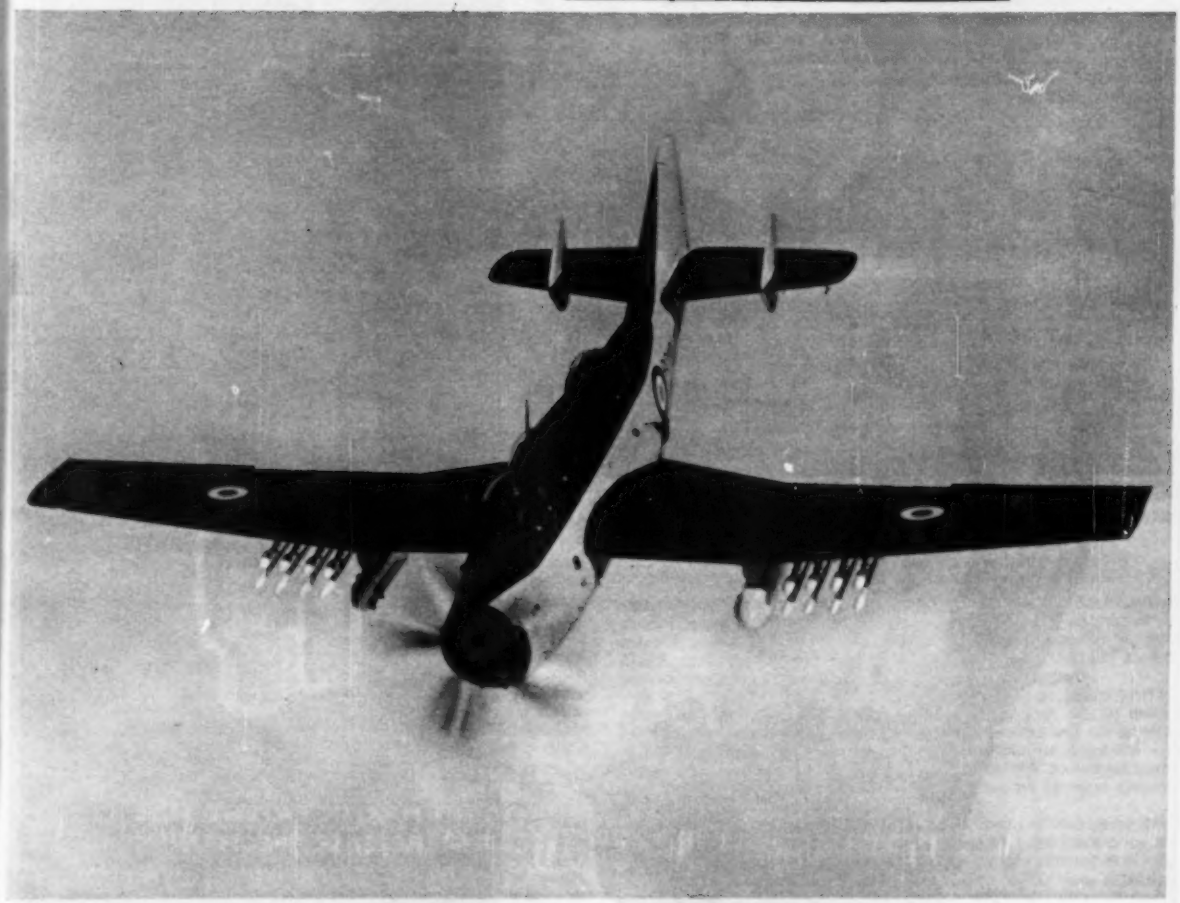
Every gas turbine so far built has suffered from an unsurmountable limitation caused by the relationship between the life of the turbine blades and the temperature at which they operate. Higher temperature means more thrust; but the life of the turbine blades at once begins to fall away, until the process is no longer worth while. Then, whatever else may be done, the practical limit has been reached. Even with the latest materials—such as Nimonic 100 or coated molybdenum, perhaps combined with blade cooling—the same argument eventually applies, albeit at a higher level. If the ram air leaving the compressor is already hot enough to melt solder, the rate at which fuel can be injected must be severely restricted if the turbine blading is to stand up to its task for a reasonable time. Reduced fuel-flow means lower thrust.

One way of easing the problem is to reduce the pressure ratio of the compressor, and this practice dictated the design of the Gyron six years ago. But at really high supersonic Mach numbers the pressure ratio of the engine is insignificant in comparison with the formidable pressure ratio generated across an efficient supersonic intake system. What is really wanted is some means of cutting the ties which join the intake, compressor, combustion



One of the most advanced present-day intakes is that of the Lockheed F-104. Although of fixed geometry it has a shock-forming (half-body) wedge and two boundary-layer bleeds, one of which is located inside the duct behind the half-body.

FAIREY GANNET

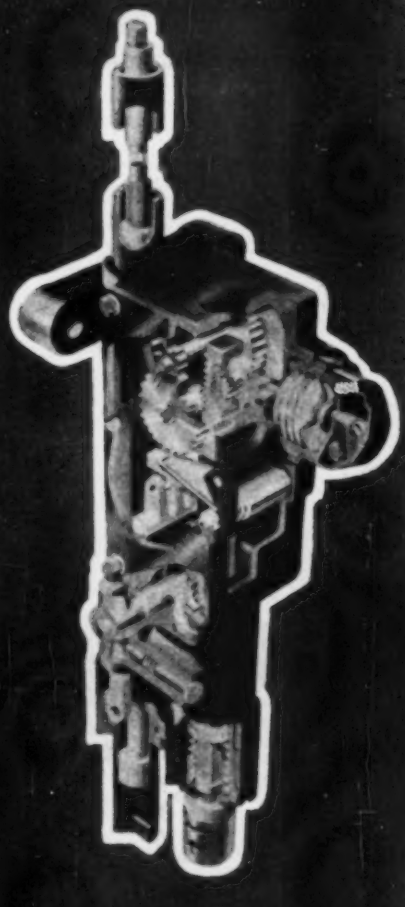


The Fairey Gannet has proved in service to be the world's most successful anti-submarine aircraft, combining the ability to search and to strike with the most formidable modern weapons. Powered by the Armstrong Siddeley Double Mamba, it has twin engine reliability. These aircraft are in service with the Royal Navy and the Royal Australian Navy and are on order for Western Germany's Naval Air Arm.

THE FAIREY AVIATION COMPANY LTD
HAYES · MIDDLESEX
ENGLAND · AUSTRALIA · CANADA

Battle injury and unconsciousness brought about by the effects of extreme high altitude or lack of time available at low altitudes, make automatic separation from the seat and deployment of the main parachute essential. The requirement has been fully met and proved, under the most adverse conditions, by the Martin Patent Time Release Mechanism fitted to all Martin-Baker Automatic Ejection Seats.

Martin-Baker Mk.4 Fully Automatic Ejection Seat.

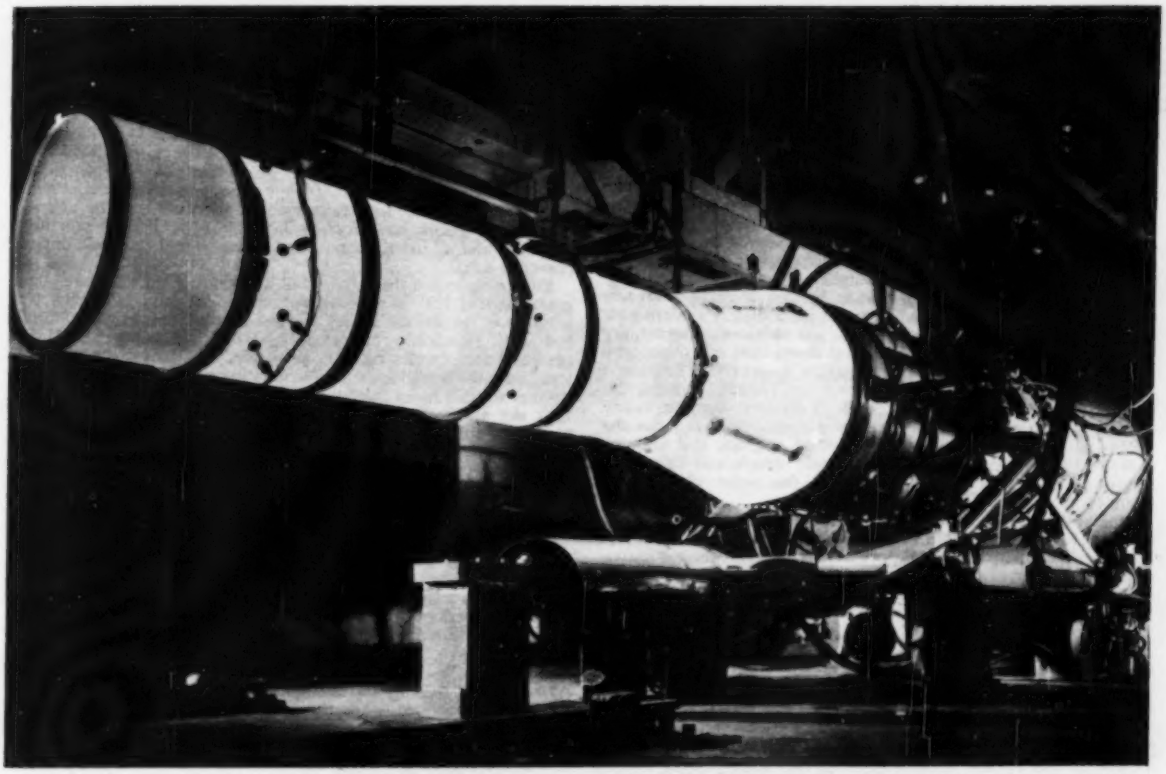


MARTIN PATENT TIME RELEASE MECHANISM

Martin-Baker

AIRCRAFT COMPANY LIMITED

ENGLAND & CANADA



Taken recently in the General Electric Flight Propulsion Laboratory at Evendale, this photograph depicts a "hack" J47 running at a turbine-inlet temperature "greatly in excess of 1,600 deg F." The increased temperature is obtained merely by injecting extra kerosine, but later engines, to be developed by General Electric and other manufacturers, will have entirely new fuels.

AERO ENGINES 1967 . . .

chamber and turbine, and of thereby giving the engine a completely new thermodynamic flexibility.

This can actually be achieved, and in several ways. One obvious arrangement which could hardly be achieved in practice, would be to install the engine under an empty bay in the fuselage of the aircraft into which the compressor/turbine assembly could be lifted bodily when the flight Mach number was high enough. Another method might be to by-pass the turbojet and feed the ram air either to an afterburner or to a separate ramjet.

This is actually being done by Wright Aeronautical in their dual-cycle project (p. 142). From a common intake, ram air is led to a large hinged flap-valve which is employed to seal off either of two distinct powerplants, an advanced turbojet and a ramjet. The former is employed for the take-off and climb. At a suitable altitude the aircraft then accelerates, perhaps by diving, until the Mach number is sufficient for the valve to be moved across to its alternative position. The turbojet is then immediately shut down (since no airflow is available for cooling) and the ramjet should simultaneously light-up and take over the propulsion. A complete dual-cycle installation would certainly be bulky and heavy and would probably pose severe development problems, but Wright are hoping to get a unit into the air next year in the Republic XF-103.

A generally similar arrangement is seen in the Leduc 022 aircraft. Here a turbojet is used for take-off, and a large ramjet—in the centre of which the turbojet is mounted—takes over for supersonic propulsion. In this case, however, the geometry is fixed, and the turbojet is presumably not shut off.

Yet another means for emancipating the combustion chamber from the restrictions of hot ram-air and limited top-temperature is to drive the turbine by an *ad hoc* rocket system. Instead of providing shaft-power to drive the compressor by mounting a turbine in the main gas-stream, the compressor rotor blades can themselves be slightly extended, out of the main gas stream, in the form of small fast-moving blades of the Laval impulse type, suitable for working in the flame from a rocket motor.

For many years various companies have driven turbines with the products of the controlled combustion of rocket propellants, and most of the problems in this respect are regarded as solved. The provision of such drive allows the engine to fly at very high Mach number, since the absence of a turbine in the main gas stream allows the temperature of the latter to reach an exceedingly high level. In addition, the thrust available at extreme altitude should be much higher than that available from a turbojet of comparable weight, since the rocket turbine shaft-horsepower should actually increase as height is gained. Such an engine is termed an air-turbo rocket, and several manufacturers in the U.S.A. (and possibly in this country) are actively engaged in the development of powerplants falling into this category.

It will be appreciated that, by varying the ratio of the rocket power to the airflow, the characteristics of the unit can be made to fall anywhere between those of a simple rocket and those of a conventional turbojet. Further flexibility can be achieved by burning conventional fuel in the efflux from the rocket-turbine, a process which is facilitated by the fact that no ignition system should be necessary.

All the engines so far considered have been of the chemical-fuel, air-breathing type, and are thus subject to the limitations of altitude imposed by the thickness of the earth's atmosphere. If one flies fast enough one can fly considerably higher than altitudes attainable by conventional air-breathing aircraft, and air-breathing missiles and test vehicles have already reached altitudes of the order of 100,000ft. The U.S. Air Force has, in fact, already issued a requirement for a weapon system (designated WS-202A) which, by flying at a Mach number of 5 and upwards, will reach altitudes very much higher than 100,000ft.

North American Aviation are at present well advanced in the development of the X-15 hypersonic research aircraft intended for the exploration of the atmosphere and outer space up to approximately 100 miles' altitude. Rocket propulsion is therefore mandatory (the unit itself is referred to on p. 139); moreover, some form of rocket system, with multiple nozzles at the tail and wing-tips, must be employed to maintain control, since beyond the atmosphere movable control surface will have no effect whatever.

Earlier in this article the point was made that, as far as the maximum thrust attainable from a turbojet is concerned, ordinary kerosine can accomplish all that could be achieved by any other chemical fuel, and that high-energy fuels are being introduced principally in order to increase range from a given tank capacity. Another and more significant method of increasing aircraft range it to employ nuclear fuel.

The term "nuclear fuel" may appear a misnomer, since it is widely believed that a nuclear aircraft powerplant consists essentially of a box housing a piece of uranium which "goes on for ever." Actually nuclear fuels may be solid or liquid or a combination of both, and they are consumed just as completely as any others (i.e., although they do not go up in smoke they soon become worn out). The advantage of nuclear propulsion is that it is today possible to design a bomber capable of carrying sufficient fissile fuel for it to remain in the air at least as long as its

AERO ENGINES 1967 . . .

crews can remain awake; this is yet another case of man's creations outstripping his own frailty. The U.S.A.F. and its contractors, such as Lockheed's Georgia Division, are intensively investigating crew-behaviour in future nuclear-powered aircraft by simulating missions lasting 120 hr (five days). Notes on nuclear powerplants actually under development are published on pages 135 and 138. At present nuclear propulsive systems are necessarily large, complex and exceedingly weighty, particularly when they have to be shielded to protect human beings, or parts of an airframe, from intense radiation. It is not immediately evident how this handicap can be overcome. Basic gas turbines, however, are more amenable to being scaled up and down than any other type of prime-mover, and it is a fair prediction to assert that engineers will eventually find a way to produce a small nuclear powerplant (using "small" in its relative sense). Certainly, one can today discern among engine-manufacturers a strong tendency for the evolution of baby versions of established engines, and also for completely new gas turbines of extremely simple and light construction capable of giving thrusts of the order of 2,000 to 5,000 lb.

One of the chief reasons for this is the omnipotent square/cube law which helps to explain why we shall never see a mosquito as big as an elephant. If, while preserving geometrical similarity, one were to make an animal twice as big (in linear dimensions) as it was previously, the monster would probably be unable to stand up; it would be four times as strong—but eight times as heavy.

It is for this reason that a small engine should have a better thrust/weight ratio than a similarly designed large one. Whatever else may be done to reduce weight, big engines cannot avoid thick metal sections, big cast casings and heavy forged parts where stress is high. To a much greater extent it is possible to make a small engine out of sheet-metal, and thus both reduce weight and cost. Few engines of truly lightweight conception have yet appeared. One of the first was the Fairchild J44, but this unit was perhaps planned too early, when the full potentialities of the technique were not appreciated, and its brochure figures are not really outstanding.

Probably the first engine capable of showing what could be achieved was the Rolls-Royce R.B.82, or Soar, which was designed six years ago. For every pound of weight the Soar gave nearly seven pounds of thrust, and its successors are substantially better. In the U.S.A. General Electric have a turbojet with a thrust/weight ratio of ten, and even this is by no means the limit. Moreover, these are not short-life engines intended for vertical lift or the propulsion of drones.

At a recent meeting of the Society of Automotive Engineers a paper was presented by Curtiss-Wright's Turbomotor Division in which that company's design-thinking for future small turbojets was lucidly outlined. A proposed turbojet rated at 2,000 pounds' thrust, for propulsion at Mach numbers of the order of 2.5, was described in some detail. There would be only two bearings, one immediately forward of the turbine and the other *behind* the compressor. The latter would only require four or five stages, and so could be very short and rigid and capable of being overhung at the front. In the absence of anything better, the nose bullet could be mounted on the compressor itself, and allowed to rotate. The geometry of the compressor was unusual, in that short, stubby blades were to be mounted on a large-diameter hub, the r.p.m. being high and the first stage being transonic.

Even at Mach 2.5 it was considered that turbine-inlet temperature need not exceed 1,200 deg K, and the suggested turbine would have one, uncooled stage. Altogether, the dry weight of the engine was calculated at the reasonable figure of 170 lb, giving a thrust/weight ratio of almost 12:1. A value of 15:1 was suggested as a target for immediate future development.

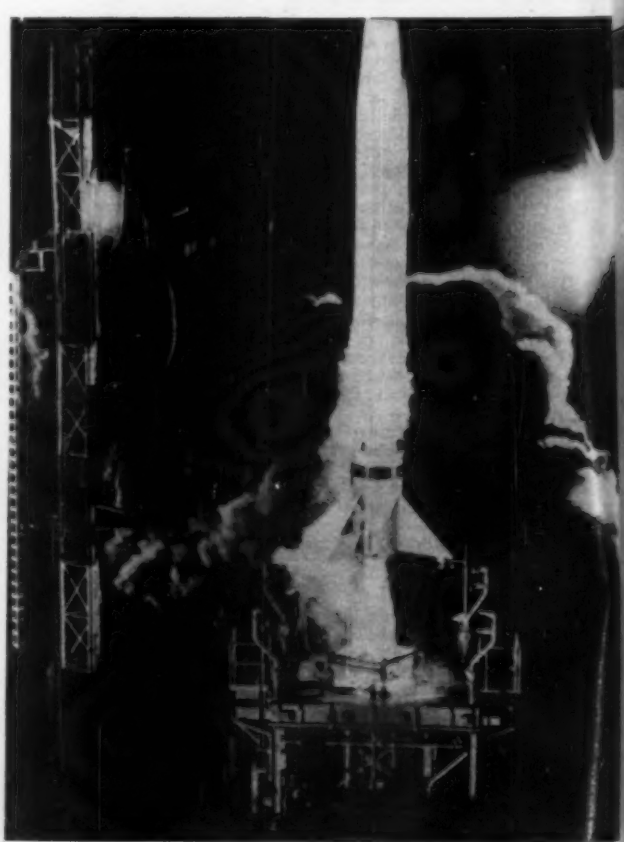
A secondary advantage of such engines is that they could be employed in clusters, and their low capital cost and ease of maintenance should keep their overhaul costs down to those of larger engines used singly. It would certainly be possible to employ four or more small engines in a single nacelle, all driving a common accessory group and perhaps even fed with fuel from a common system employing one pump and one set of controls. The latter arrangement, however, might be frowned on by the authorities responsible for certification of the aircraft concerned.

An offshoot of this idea, but employing a final shaft-drive, has been suggested in France. Three small turbojets—the Viper was actually cited—are mounted in a group within a common nacelle, and their jet-pipes are coupled to a volute casing surrounding a single turbine rotor of very large diameter, which is coupled to a propeller. The advantages are that multi-engine reliability is obtained in a very flexible powerplant, that the large-diameter turbine can extract full power while turning at very moderate r.p.m. and so eases reduction-gear problems, and that the "fluid-drive" character of the completely free power-turbine system would permit a fixed-pitch propeller to be used. The overall powerplant weight was given as 3,090 lb (3,900 lb with cowling, propeller and all installational requirements) and the shaft horsepower as 6,800.

Returning to the theme of small turbojets, there still remains a great deal of life in the concept of the jet-flap, pioneered by workers at the British N.G.T.E., and by others in France. Only last week Fairchild were given a $218,000 contract to study a configuration employing this principle, and many other firms and government agencies are formulating plans. Essentially, the jet-flap aircraft has a fixed wing propelled by a jet issuing from a thin slit along the extreme trailing edge. The jet effectively separates the flows above and below the wing and thus makes some of the most fundamental dictates of traditional aerofoil theory inapplicable. It would, of course, be possible to achieve partial jet-flappery with present turbojets, but the ideal solution—from the viewpoint of the aerodynamicist, if not from that of the operator—would be to employ small turbojets disposed right across the span. It may, in fact, be possible to employ engines lying spanwise within the wing—or to adopt some entirely new method of jet-generation. Possibly the entire wing could be employed as a two-dimensional ramjet.

The suggestion just made may well be quite impracticable, but one may rest assured that it will not be dismissed as such until it has been tried, exhaustively evaluated and proved to be not worthwhile. It is never a good policy to discourage enthusiastic promoters of new ideas, but amateur inventors the world over might be surprised to see the suggestions which are even now being studied by such competent groups as the N.A.C.A., the R.A.E., O.N.E.R.A.—and, of course, Soviet workers at TsAGI. It is frequently held that the day in which an inventor could really be said to invent are over, and that everything has already been done—or at least started to be done. When one regards the flight-propulsion scene it certainly looks like it. Even electro-gravitics, or the negation of gravity by electrostatic or other means, is already in the "hardware" stage. But that will not lead to a powerplant by 1967 . . .

W. T. G.

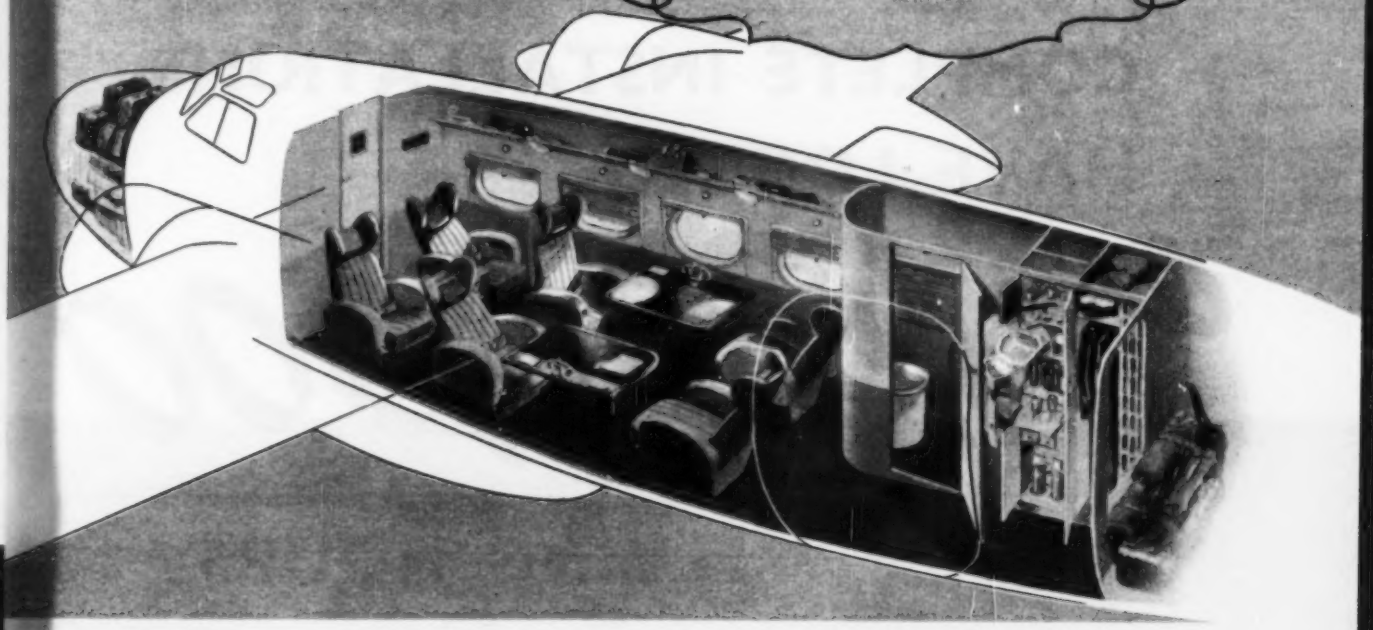


Although perhaps not directly connected with the development of aero-engines for 1967, this photograph is of dramatic quality and illustrates a possible method of airline take-off in 1987. The subject actually shown is a two-stage vehicle which was fired from Patrick A.F.B. two months ago as part of the earth-satellite-vehicle programme.

THE EXECUTIVE

President

Two Alvis "Leonides" engines



EXECUTIVE AND CHARTER AIRCRAFT

✳ *Increased Performance*

✳ *Greater Range*

✳ *Proven Reliability*

Civil counterpart of the Pembroke—in service with the Air Forces of seven nations

ACCOMMODATION 6 passengers, their luggage, and a crew of two. Other versions of the President have accommodation for 12 passengers.

PERFORMANCE Take-off distance to 50 ft. (15 m.) 2250 ft. (686 m.)
Cruising speed 204 m.p.h. (328 km/hr.)
Stage lengths up to 1555 miles (2490 kms.) can be flown with reserve fuel for 30 minutes stand off.

The executive President is a personal airliner for the business man—the man of industry—the man who has no time to waste . . . . . .

HUNTING PERCIVAL AIRCRAFT LTD

A Hunting Group Company

LUTON, BEDFORDSHIRE, ENGLAND and at 1450 O'CONNOR DRIVE, TORONTO, CANADA

GRAVINER
FIREWIRE

COMPLETE INSTALLATIONS HAVE LOGGED

over 1,500,000

FLYING HOURS

INDIVIDUAL ELEMENTS HAVE LOGGED

over 1,500,000

FLYING HOURS

GRAVINER MANUFACTURING COMPANY LIMITED · COLNBROOK · BUCKS

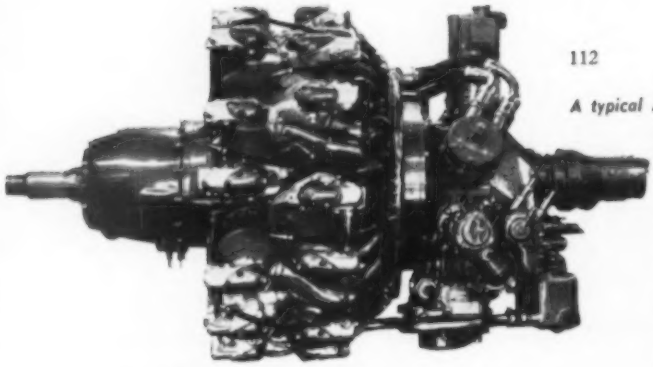
TELEPHONE · COLNBROOK 48

G46

Aero Engines 1957

HE who essays a study of a rapidly changing field like that of aircraft propulsion must expect surprises when he pauses to survey the scene at any given time. After perusal of the following pages—wherein the Technical Editor summarizes the work of the world's aero-engine companies—the reader may find it scarcely credible that 20 years ago all aircraft powerplants were piston engines, with their designers arguing heatedly the relative merits of air cooling or liquid cooling, sleeve valves and poppet valves, in-lines and radials. . . . Today the propulsion of flying vehicles has become a subject so vast that no man can hope to master all of it. Typical of the contrasts which this science presents are the Wellsian scene of rocket-testing below and the traditional piston engines with which, overleaf, this review opens.

The drawings *which illustrate this review are "Flight" copyright illustrations; they are not to scale.*



A typical Alvis Leonides Major for fixed-wing aircraft.

AERO ENGINES 1957 . . .

GREAT BRITAIN

ALVIS. *Alvis, Ltd., Holyhead Road, Coventry.* After a great deal of pre-1939 development on radial engines of French origin, Alvis managed the production of tens of thousands of Merlins during World War 2. In 1944 the Ministry of Aircraft Production placed a development contract for a nine-cylinder radial of about 500 h.p., and this unit has since become world-famous as the Leonides.

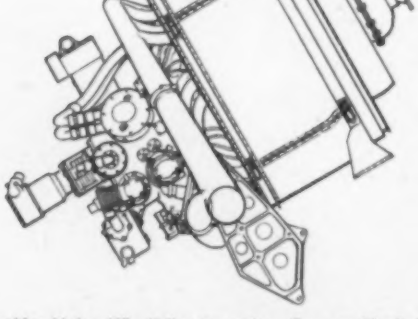
Production of this engine has been in progress for nearly a decade, and it has now been joined by the slimmer and more powerful Major. Both engines have particularly important rotary-wing applications. Gas-turbine work has not so far been officially acknowledged by the company, but it is understood that before many months have passed an announcement will be made of the decision to enter this field. It has been suggested that the first Alvis gas-turbine will be a turboshaft unit in a power-class with which the company are already familiar, and that it will be developed jointly with another British company already working on turbine aero engines.

Leonides Major. Depicted in the drawing is one of the most important engines in this family. Fitted with a direct drive, cooling fan and clutch, it is installed in the Westland Whirlwind H.A.R.5, and also in the newly revealed H.A.S.7. The first batch of helicopter Majors was company-sponsored, but full production is now in hand for the Royal Navy, both for the aircraft mentioned above and for re-engining existing Whirlwinds. A generally related engine is the Leonides Major 151, installed vertically in the first version of the Bristol 192. In order to provide improved single-engine performance this engine has a maximum rating (which is also the one-hour rating) of 860 h.p., at 2,900 r.p.m. and +9 lb boost. Major 151s are flying in a Bristol 173.

Fixed-wing Majors are now well advanced in development, and have flown more than 2,000 hr, with several times as long on the bench. Chief application concerns the Handley Page Herald, the powerplants of which are rated at 875 b.h.p. at 3,000 r.p.m. (100 more than helicopter engines) at +9½ lb boost. The engine has been built up into a neat and efficient powerplant, complete with petal cowling, and driving a three-blade reversing D.H. propeller. The Major may also find other fixed-wing applications, and discussions are in hand with several overseas aircraft companies.

Leonides. Little change has occurred to this trim, single-row engine during the past year, although Service experience—in both military and civil fields, and in fixed-wing machines and helicopters—continues to build up. Already the Leonides has flown more than one million hours with the R.A.F. alone.

Chief fixed-wing applications concern the Hunting Percival Provost, Pembroke/Prince/President series, Scottish Aviation Prestwick Pioneer and Twin Pioneer, and various other types such as the Agusta Az-8L, C.A.S.A. Alcotan and M.H.250 Super Broussard. Helicopters powered by the Leonides include the Sycamore, Dragonfly and Widgeon. In all these applications the basic engine has nine cylinders of the same size as those of the two-row Major, fed with fuel from an injection-type Hobson carburettor. Helicopter units have a direct drive, cooling fan and clutch, and the Sycamore engine is mounted with crankshaft vertical.

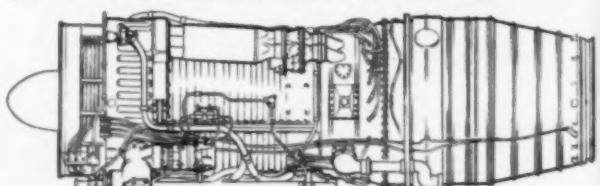


Alvis Leonides Major 153. Helicopter engine. Two-row 14-cylinder piston engine mounted in the Whirlwind at 35 deg with supercharger and direct drive with cooling fan. Overall diameter, 38.9in (basic engine); length as shown, 54.86in; bore, 4.8in; stroke, 4.41in; swept volume, 1,118 cu in; dry weight, 1,050 lb; one-hour rating, 780 h.p. at 4,250ft at 2,900 r.p.m. with 6½ lb/sq in boost; weak-mixture rating, 585 h.p. at 11,000ft at 2,800 r.p.m. with ½ lb/sq in boost.

ARMSTRONG SIDDELEY. *Armstrong Siddeley Motors, Ltd., Parkside, Coventry.* Pioneers in Britain of axial gas turbines, Armstrong Siddeley have developed an extensive range of small turboprop and turbojet units since World War 2. They have also developed—to another company's original conception—and mass-produced an extremely successful large turbojet, the Sapphire, which is licence-produced by Wright in the U.S.A. (as the J65, *q.v.*) and will also be manufactured in another overseas country. For the immediate future the Sapphire will remain the company's "bread and butter" engine, supplemented by the smaller Viper; turboprop development is likely to be directed towards completely new powerplants quite unrelated to the company's earlier units. In addition, licence-production will shortly begin on small gas-turbine compressor sets designed by AiResearch (U.S.A.). Armstrong Siddeley Motors maintain a strong interest in rockets, referred to below, and in several non-aeronautical fields.

Headquarters are at Parkside in the original Siddeley works of 1906, which is now engaged in the production-assembly of the Double Mamba and Viper and in general machining operations. Also at Parkside are the test beds for Double Mamba and Viper engines, a variety of test rigs and laboratories and overhaul and test operations on Cheetah piston engines. At Ansty, outside Coventry, is a new engineering building housing drawing offices, experimental departments and related branches. The assembly and test of development engines is undertaken here. Ansty also houses the entire Rocket Division and the A.S.M. school and service department. At Brockworth, Glos, is a large and well-equipped factory responsible for the production and testing of the Sapphire and repair and spares-manufacture for the Sapphire, Wright J65 and Orenda. Brockworth also manufactures the company's range of air-cooled diesel engines. Flight-testing is based at Bitteswell, near Coventry.

New Turbojet. Although never built, this engine deserves a place in this review. It is now common knowledge that it would have been the engine of the Avro 730 supersonic bomber (and it would have borne considerable resemblance to the hypothetical engine illustrated on pages 562-3 of our 1956 aero-engine review). The engine naturally had the utmost priority, and Armstrong Siddeley assigned to it virtually their entire research and development strength. Without prior notice, the whole programme was cancelled early this year, when the engine was in the hardware stage. This unhappy history inevitably delayed the company's reappraisal of existing markets and prevented them from having a ready-made entry to the commercial field.



Armstrong Siddeley Sapphire ASSa.7. Single-shaft turbojet. Thirteen-stage compressor, annular combustion chamber with 24 burners and two-stage turbine. Overall diameter, 37.4in; length as shown, 132in; dry weight (including anti-icing, turbo-starter, high-energy igniters and oil tank), 3,075 lb; maximum thrust, 11,000 lb at 8,600 r.p.m. with s.f.c. of 0.885. Other data on this engine are restricted. With a 12 per cent reheat jet-pipe this engine weighs 3,450 lb and has a rated thrust of 12,300 lb with s.f.c. of 1.2. The overall length of the unit is then 293in.

Sapphire. First-generation Sapphires of the 100-series entered production in August 1953 and many hundreds were built before the Brockworth plant switched to the 200-series late in 1956. Including engines built by Wright as the J65 (*q.v.*) well over 11,000 of these engines have been manufactured, and their flight time is in excess of one million hours. As the powerplant of the Hunter 2 and 5 and the Javelin, the Sapphire 100-series are rated at from 8,000 lb (ASSa.6) to 8,800 lb (ASSa.12). Their performance in Fighter Command is exceptional and their serviceability rate normally surpasses that of all other R.A.F. fighter engines.

Depicted in the drawing is a typical engine of the second-generation, or 200-series. The later Sapphires are almost completely redesigned, with much greater mass flow and pressure ratio and give extremely high thrust for a reduced fuel consumption. Engines at present being built—for, one may conclude, the Javelin and Victor—now embody j.p.t. control. A Sapphire 202 recently completed a 150-hr run with 1st-stage compressor blading of glasscloth laminate. A new feature, mentioned in the data, is the addition of a simplified form of reheat, which has been developed on the bench and in flight and will shortly go into operational service. As the augmentation is needed only at altitude no additional fuel pump is required; jet-pipe diameter remains substantially unchanged and a two-position nozzle of unusual design is incorporated.

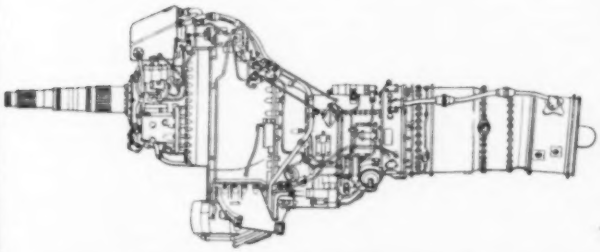
The Sapphires 8 and 9 were believed to be exceedingly high-thrust fighter engines with cooled blading and other changes. Armstrong Siddeley also completed studies for a lightweight commercial derivative of the Sapphire 100-series which would have weighed less than 2,000 lb and had an exceedingly competitive performance.

Viper. Originally a short-life engine for the Australian Jindivik target, the Viper is now branching out into a large family of small

turbojets for a variety of civil and military applications. At present in service with the Jet Provost, which has been ordered into substantial production as the standard R.A.F. basic trainer, the ASV.8 is rated at 1,750 lb-thrust and is rapidly acquiring an exceptionally good overhaul life. Recent modifications include hydro-mechanical fuel-pump governing and redesigned centre sections, one of stainless steel and the other of zirconium. The ASV.8 will soon fly in the Macchi MB.326; it has been sold to Yugoslavia for use in the Ikarus fighter, and Poland and Czechoslovakia have requested purchase of the engine. The ASV.8 has also been shipped, *via* Wright, to Bell Aircraft for use in the X-14 VTOL machine, All-American Engineering having developed the deflecting nozzles. Rated at 1,900 lb-thrust the ASV.9 is a hot-running ASV.8 for VTOL applications.

Illustrated is the ASV.10, which is completely redesigned and is more akin to a baby Sapphire. First run early last year the engine immediately achieved its brochure thrust of 2,000 lb with a turbine-entry temperature substantially lower even than that of the ASV.8. When run at what may be called "normal" top-temperature the engine becomes the ASV.11 of 2,460-lb rating, and higher ratings are in prospect. Future development is likely to be directed towards the achievement of maximum life and minimum cost and weight. Developments of the Viper are also mentioned under Dassault (France).

Mamba. In our 1956 review we described the Mamba 6, of which a batch was built to power the Seamew. From this was evolved the civil Mamba 7 and the Mamba 8 which forms the half-unit of the new Double Mamba 8. Flown in the Armstrong Siddeley Dakota, the Mamba 8 had a very fine type-test in April at corrected powers as high as 2,020 s.h.p.

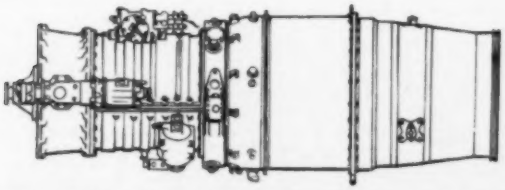


Armstrong Siddeley Double Mamba ASMD.8. Double turboprop. Two mechanically independent power sections, each driving one unit of twin co-axial propellers; each power section comprises a Mamba 8, with 11-stage compressor, annular vaporizing combustion chamber and three-stage turbine. Overall width, 56.55in; height, as shown, 45.28in; length, 109.7in; maximum rating, 1,800 s.h.p. plus 300 lb-thrust per side, a total of 3,850 e.h.p. All other data restricted. This engine is cleared to run on ship's diesel fuel.

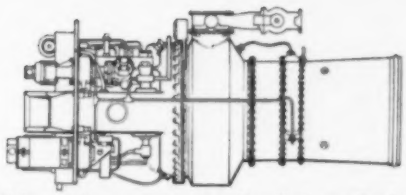
Double Mamba. Some hundreds of ASMD.1 engines are now in service with Gannets of the Royal Navy and Royal Australian Navy, and production has for over a year been concentrated upon the more powerful ASMD.3, described in our 1956 review. Service performance of the engine is good, and, to clear the engine to retain full power in tropical conditions, it is proposed to raise the maximum-continuous rating to that specified for take-off. The ASMD.3 will shortly enter service with the German Navy in the Gannet A.S.4.

Depicted in the accompanying drawing is the completely new ASMD.8, which is now coming into production. Derivation from the Mamba 6 can be deduced from the increased number of compressor and turbine stages and the truly annular combustion chamber. Equipment includes a Rotax low-pressure pneumatic starter, suitable for use in conjunction with an Armstrong Siddeley (AiResearch) compressor set. A noticeable design change in the new engine is the lower thrust-line. It may well be that the engine is fitted to the early-warning Gannet 3, the large radome of which has raised the fuselage position, thus requiring that the engine should have a relocated propeller-shaft.

Rocket Motors. In our issue of July 27, 1956, we described the Screamer liquid-oxygen controllable-thrust aircraft motor, which unfortunately never went into production owing to official disfavour with its propellant combination. Nevertheless, the company's recruiting campaign and the noise of test-firing at Ansty reveal that rocket development is expanding and the company are clearly heavily committed in this field. No doubt it will soon be possible to show achievements in the propulsion of major weapon systems. Work is going ahead on several propellant combinations, including H.T.P.



Armstrong Siddeley Viper ASV.10. Single-shaft turbojet with low top-temperature. Seven-stage compressor, annular combustion chamber with 12 vaporizing burners and single-stage turbine. Maximum diameter, 24.3in; overall length, 68.1in; mass flow, 42 lb/sec; pressure ratio, 4:1; dry weight, 570 lb; maximum thrust, 2,000 lb at 13,400 r.p.m. with s.f.c. of 1.01.



Blackburn Palouste. Air-compressing gas turbine. Single centrifugal compressor, annular combustion chamber with rotating fuel-injection nozzles, and single-stage turbine. Maximum diameter, 17.7in; height, about 18in; length, basic engine, 28.62in; dry weight, 178 lb; delivery 2,725 lb/sec air at 41.55 lb/sq in gauge, with fuel consumption of 310 lb/hr. This unit is fitted to the Fairey Ultra-Light.

BLACKBURN. *The Engine Division of the Blackburn and General Aircraft Company, Ltd., Brough, East Yorks.* Although principally an airframe company, Blackburn can trace their lineage of engines right back to the original A.D.C. Cirrus which appeared shortly after World War 1. The company's last piston engine was the Bombardier, an inverted four-in-line unit of particularly modern design fitted with direct fuel injection and an exceptional range of accessories. Limited production has taken place for the Auster A.O.P.9 and a helicopter variant has flown in the Saro Skeeter helicopter.

In 1952 the Blackburn company decided to enter the field of small gas-turbines, and purchased from Turboméca a licence to develop and manufacture all the French company's engines up to a specified limit of mass flow (which excludes the Marboré). Considerable effort was expended in converting the French experimental engines into fully equipped powerplants capable of doing an operational job installed in an airframe. A revised front end was evolved, with a bifurcated intake integral with the front-end casting, together with trains of spur gears above and below providing mounting-pads for all required accessories. Two main families of engines have so far been evolved, distinguished from each other by a difference in mass flow (in the ratio 4.7 : 7.2). The 600-series units are the more important for aircraft propulsion, and the 500-series have slightly better specific consumption and are more attractive for industrial applications.

Palouste. As the powerplant of the Fairey Ultra-light helicopter the Palouste has been built in small numbers and may yet go into full production for that aircraft. The excess air delivery is obtained by matching a 600-size compressor with a 500-size combustion chamber and turbine.

Blackburn hold a production contract for the supply of Palouste-powered air-compressor trolleys for the Royal Navy. The air supply, at about 40 lb/sq in, is taken through a hose to a suitable connection on advanced carrier-based aircraft, and used to operate pneumatic starters for the main aircraft powerplants. Secondary rôles of these compressor sets include ground air-conditioning and the energizing of accessory systems for functional testing.

Palas. Basic unit of the Blackburn turbines, this 355-lb-thrust turbojet has been built in small numbers for such aircraft as the S.K.1 and Sparrowjet; two Palas may also be fitted to the Miles Student.

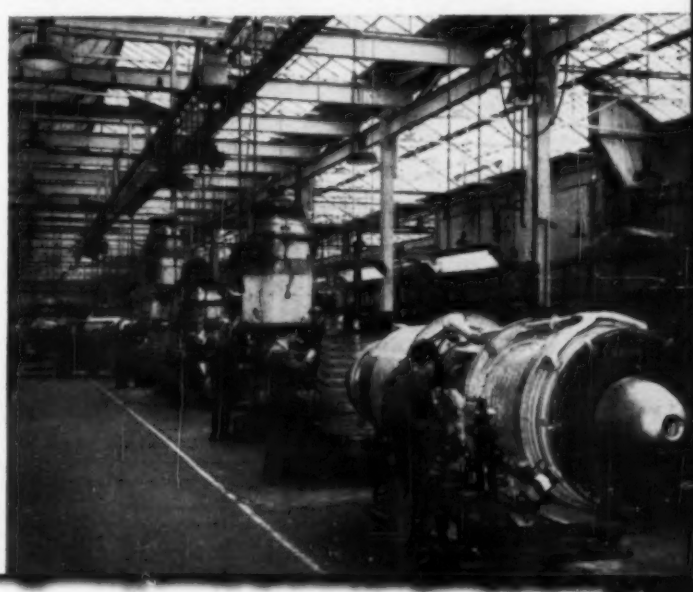
Artouste. The Artouste 610 single-shaft turbine is in production as the prime mover of an airborne auxiliary powerplant (A.A.P.P.) fitted to a British bomber. The Artouste is operated at constant r.p.m. and is thus able to drive an alternator giving parallel-A.C. supply.

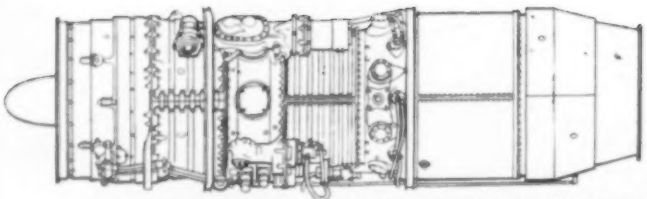
Turmo. Likely to be built in large numbers for use in various fields, most of them not connected with aviation, the Turmo has a free power-turbine at the rear end. In the American Kaman K-17 helicopter a Blackburn Turmo drives a compressor which feeds air to pressure jets at the rotor-blade tips.

BRISTOL. *Bristol Aero-Engines, Ltd., Filton House, Bristol.* After fifteen years of work Bristol Aero-Engines—formerly the Engine Division of the Bristol Aeroplane Company—are at last reaping a reward in the field of advanced gas-turbines. That it has taken so long in no way reflects upon the ability of the company, which is outstanding. Rather does it result from vaccillating official requirements and the fact that the engines concerned break new ground in a number of fields.

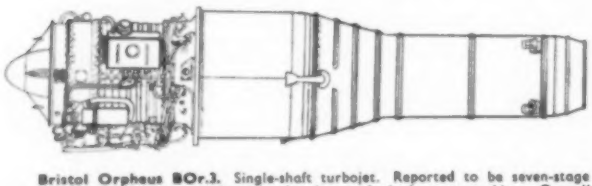
First Bristol turbine to enter service was the Olympus two-spool turbojet. Within a few months it was followed by the Proteus free-turbine turboprop, and both these large and complex engines are now well established in military and civil operation and are proving extremely reliable. The smaller and simpler Orpheus turbojet is now branching out into a family of units, of which the first versions are fully developed and flying in several types of aircraft. For the future, an advanced family of Olympus engines is in production for military applications,

Production of the Bristol Olympus 103 turbojet of 13,000 lb thrust.

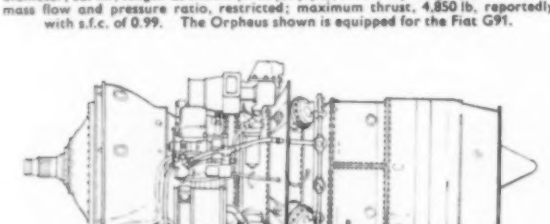




Bristol Olympus BOl.6. Two-spool turbojet. Inspection shows that there is a five-stage low-pressure compressor, a seven-stage high-pressure compressor, a can-annular combustion chamber with eight flame-tubes, and independent single-stage high-pressure and low-pressure turbines. Overall diameter, 40.875in; overall length as depicted, 152.34in; dry weight, mass flow and pressure ratio, restricted (but see specification for Wright TJ-38 in U.S. section); maximum thrust, 16,000 lb (r.p.m. and s.f.c. restricted). This engine will power the Vulcan B.2.



Bristol Orpheus BOr.3. Single-shaft turbojet. Reported to be seven-stage compressor, annular combustion chamber and single-stage turbine. Overall diameter, 32.4in; length as shown (with jet pipe), 150in; dry weight, about 750 lb; mass flow and pressure ratio, restricted; maximum thrust, 4,850 lb, reportedly with s.f.c. of 0.99. The Orpheus shown is equipped for the Fiat G91.



Bristol Orion. Split-compressor, power-limited turboprop. Seven-stage low-pressure compressor, five-stage high-pressure compressor, annular combustion chamber with ten flame tubes, single high-pressure turbine stage and three-stage low-pressure turbine coupled to the reduction gear and airscrew. Diameter, 41.8in; overall length, 112.3in; dry weight, 3,150 lb; mass flow, 82 lb/sec; pressure ratio, over 10:1; maximum take-off power, maintained up to 15,000ft (i.s.a.), 5,150 e.h.p. (4,400 s.h.p.+1,950 lb thrust) at 10,000 l-p. r.p.m. with s.f.c. of 0.64; maximum continuous rating, maintained up to 25,000ft, 3,900 s.h.p.; cruising rating at 36,000ft at 350 kt, 3,300 e.h.p. with s.f.c. of 0.40.

AERO ENGINES 1957 . . .

and a related engine, the Zephyr, will shortly be available for commercial use. Also well advanced in development is the Orion turboprop, and the B.E.47 is a medium-thrust turbojet. Bristol remain leaders in ramjet propulsion and are still producing advanced piston engines, albeit at a low rate.

Total employment of Bristol Aero-Engines is roughly 16,000. The main works is north of Bristol in the Filton/Patchway area. Company-owned research, development and test equipment is very extensive and of impressive ability. The latest establishment is a large-scale facility for high-speed ramjet testing at conditions appropriate to extreme altitudes, and it will shortly come into full operation. A branch factory is located at Sunderland, Durham, and drawing offices are situated in London and Cardiff. Bristol have for many years maintained technical collaboration with Wright Aeronautical (U.S.A.) and William H. Allen, a large British gas-turbine and piston-engine (non-aeronautical) firm. The former agreement is of major importance, in that it may lead to the establishment of Bristol engines in North America with Wright acting as the manufacturer (see Wright, and also the Zephyr engine, below). Bristol hold licences granted by S.N.E.C.M.A. (France) in respect of thrust-reverse mechanisms, and Solar (U.S.A.) in respect of afterburner systems. In return Bristol engines are being licence-built by S.N.E.C.M.A. (Hercules), and the Orpheus will be licence-produced by Hindustan (India), and probably by Fiat (Italy) and in other countries.

Olympus. Since 1954 the first-generation, or 100-series, of the Olympus has been in production as the powerplant of the Vulcan B.1 medium bomber. After initial development in the period 1950-1953 at 9,250/10,000 lb-thrust, the first definitive model entered production at 11,000 lb dry-thrust as the Olympus 101. In spite of its relative complexity, it being the first split-compressor, high-pressure, engine to reach the R.A.F., it has already built up an outstanding record for good handling and complete reliability.

Early last year an up-rated version of the 101, known as the Mk 102, succeeded the earlier engine on the production line. Clearly fitted with a zero-stage on the compressor, the 102 in consequence has increased mass flow and pressure ratio, and is rated at 12,000 lb. In turn, the 102 has now been succeeded by the Olympus 103, rated at 13,000 lb. It is possible to convert the 102 to operate at 103 rating in the field, a fact which suggests that the increased thrust is obtained by making minor changes to permit operation at a higher top temperature.

Early engines of this first Olympus generation were shipped to Wright to form a basis for the U.S.A.F. J67 engine. It is also likely that these engines have been operated with Bristol Simplified Reheat, a means for obtaining limited thrust-augmentation, and possibly with complete after-burning jet-pipes. A Canberra fitted with series-102 engines holds the world altitude record, at 65,890ft.

Development effort is now centred chiefly on the second-generation Olympus 200-series, of the BOl.6 rating of 16,000 lb. These new engines are of fundamentally later conception than the earlier Olympus, and are designed to incorporate all that had been learnt about gas-turbines up to about 1953. The new compressor is designed to pass far more air than that of the earlier Olympus, and certainly operates at a similar pressure-ratio, yet it actually has fewer stages and is in all probability lighter. The exterior of the engine is extremely "clean," and the Lucas fuel-system components are in a compact group beneath the h-p casing. Each rotative assembly in the engine drives one D-size pump and one oil pump; the oil tank is inside the nose bullet. Typical equipment includes an electric starter geared to the h-p. assembly, a Dowty Vardel hydraulic pump and an English Electric/Sundstrand drive.

The first of the new family went on to the bed on September 27, 1954. Since that date development has been outstandingly successful, and a full type-test—followed by a magnificent strip—was completed in January of this year. The figure proved at this test was 16,000 lb, then the highest such rating achieved by any engine in the West. Corrected thrusts have reached 17,000 lb for one hour and 17,500 lb for 30 min, with blading of a type which has since been superseded by later patterns.

One of the most important applications for the 200-series engines would have matched afterburning versions with a Gloster supersonic all-weather fighter. This programme was eliminated in 1955. Without an afterburner the BOl.6 is now in full production as the powerplant of the advanced Vulcan B.2, and one of Bristol's primary tasks at present is the proving of the various new accessories required for this installation.

Zephyr. Under this name Bristol Aero-Engines have evolved an extremely attractive commercial turbojet from the military 200-series Olympus. Originally it had been envisaged that the BOl.6-rated civil engine would be the Olympus 510 series, fully rated to give a thrust in the bracket 15,000/19,000 lb. The Zephyr, however, is intended for a somewhat different market.

Compared with the military engine it runs considerably cooler. This confers numerous advantages, particularly in the areas of engine life and noise-level, and also in making possible the achievement of an extremely low specific consumption. The Zephyr also introduces a certain admixture of Orpheus design-features, and differs from the advanced Olympus in numerous details.

Bristol undertook the evolution of the Zephyr in co-operation with Wright Aeronautical, and the American company are marketing the engine as the TJ-38 (*q.v.*). As the specification (see Wright in U.S. section) shows, it is appreciably better than competing engines which are also less-advanced in development.

Orpheus. Begun in 1953 as the private-venture B.E.26, this simple turbojet is now a very successful unit embracing a long line of development stages. Bristol have succeeded in giving the Orpheus almost unique qualities in its combination of high thrust/weight ratio, low cost and extreme reliability. Its equipment includes a full range of accessories, a twin-breech cartridge starter in military engines, Bristol Simplified Reheat (if required) and a reverse-thrust nozzle capable of exerting on the airframe a net retardation of 1,500 lb.

Internal detail may not be released, but an American published description avers that the engine is a two-bearing design with stress-bearing casings. The compressor is stated to have seven "button-on" stages and the combustion chamber is described as a can-annular design with wrapped and welded Nimonic inner and outer liners housing separate flame-tubes, the rear ends of the latter carrying the segments of the turbine nozzles.

The first prototype ran in December 1954. Only five months later the BOr.1 special-category rating of 3,285 lb was type tested to enable the engine to power the Folland Gnat in the summer of 1955. The standard Gnat engine is now the BOr.2, of 4,520 lb rated thrust, and this engine is in full production for Gnats for the M.o.S., Finland and India. India is also likely to manufacture the BOr.2 under a licence-agreement; this will be the first gas turbine to be made in non-Communist Asia.

Most important of the current range of engines is the BOr.3 of 4,850 lb-thrust. This unit was fully type-tested earlier this year, and it marks the successful completion of the first generation of Orpheus development. It is similar to the BOr.2 except for the provision of an increased-capacity fuel pump, which permits higher thrust to be achieved below about 10,000ft, a factor of particular importance to the NATO ground-attack machines for which the BOr.3 is intended. It is flying in the Fiat G91 and Dassault Etendard 6, and is soon to fly in the Bréguet 1001. The engine is also scheduled to power the Hispano XC-6 or HA-300, the Aerfer Leone, the Fuji TIF-1 and other aircraft. A licence to produce the BOr.3 is held by S.N.E.C.M.A. (France).

An offshoot of the first series of Orpheus is a derated, lightweight, long-life unit of BOr.4 rating (4,230 lb). This engine is intended for trainer or transport applications, and it may find its first employment in the U.S.A. Engines have already been shipped to Lockheed for the CL-329 executive and combat-readiness transport, and North American cite it as an alternative powerplant for the Model 249 trainer.

Later Orpheus are substantially more powerful. Ratings which may be quoted include those of the BOr.11, rated at 5,760 lb and serving as an advanced version of the BOr.12. The latter, being developed against MDWP funds for use in NATO light strike aircraft, will have a dry thrust of no less than 6,810 lb, and reheat will raise this to nearly 8,000 lb.

B.E.47. Earlier this year the Ministry of Supply announced the B.E.47 as a turbojet rated at 6,000 lb thrust, and shortly thereafter a supplementary statement asked that the thrust should be described as being "6,000 to 8,000 lb." Bristol have yet to make official reference to the engine. It has been reported unofficially that the B.E.47 is a high-pressure commercial turbojet, of very light weight and high efficiency, stemming initially from the Orion turboprop. Four were once described as being mounted in nacelles flanking the rear fuselage of the Bristol 200 transport project.

Proteus. It is unfortunate that the first applications of the Proteus concerned the Brabazon and Princess, since these projects gave the engine a reverse-flow layout and caused much time to be wasted on coupled projects, and also held up the pace of development. A new series of Proteus was run in 1952 as a Britannia powerplant, and this engine is now by far the most highly developed large commercial turboprop in the world.

The Proteus was last described in our issue of August 12, 1955. Equipment includes Ultra electric temperature control, hot-air de-icing, compressor bleed for cabin pressurization, auto-synchronization, auto-decoupling by an overspeed senser on the power-turbine drive and a double-helical reduction gear incorporating a hydraulic torquemeter.

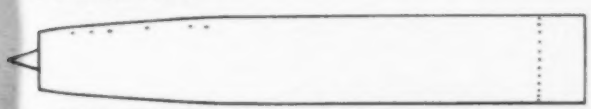
Present Britannia 102s are powered by the Proteus 705, of which production is complete. Rated at 3,480 s.h.p., or 3,900 e.h.p., these engines have completed some 50,000 hr in scheduled B.O.A.C. service, backed up by approximately the same time in development running. In spite of its mechanical complication it is an extremely reliable engine; it is normal practice to work a Britannia service to Johannesburg and back to London (13,600 miles) without once opening the cowlings, and even after the round-trip the maintenance man-hours do not reach double figures. The present overhaul life is 850 hr, and a further increase is in prospect.

Giving a maximum of 4,120 e.h.p., the Proteus 755 powers the heavier Britannia 300/310 series, and is in full production. When the initial flying of the Britannia 312 revealed a small percentage deficiency in range, minor improvements were made to the engine to reduce the specific consumption and raise the power, and the results of these modifications are now being explored. Present indications are that the brochure performance of the long-range Britannia has been more than restored.

Orion. Fully described in our issue of October 26, 1956, the Orion was designed to achieve a cruise power of 3,500 h.p. at 30,000ft with a fuel consumption at least as good as that of the most efficient piston engine. The engine was also planned as the first derated, or supercharged, gas-turbine, in that it is not a full-throttle engine at sea level. The fuel flow is restricted below 20,000ft to hold output at 4,400 s.h.p., a rating admirably suited to a range of transport aircraft, including advanced types of Britannia such as the series 450. Thus no penalty on aircraft performance is imposed by airfield height or ambient temperature.

Orion development is continuing, on schedule, with bench running to prove mechanical reliability and flight trials in the original Britannia prototype. Engines to production standard should be running at the end of this year. The Orion is the powerplant chosen for the Canadair CL-44 military transport, ordered by the R.C.A.F. for delivery in 1959.

Piston Engines. The only unit still in production is the 18-cylinder, sleeve-valve Centaurus, for the Beverley transport. This engine was described in our 1956 review, and a direct-injection version was described on November 16 last.



Bristol Thor BT.1. Supersonic ramjet. Fixed-geometry double-shock intake, circular-section body housing diffuser and combustion chamber, centre-body housing fuel system, convergent/divergent propelling nozzle. Overall diameter, about 16in; overall length, about 109in; weight and performance, restricted. It has been stated that a theoretical horse-power of about 90,000 could be developed at Mach 3 at sea level.

Ramjets. At present all Bristol ramjet development and production is undertaken for the M.o.S. and very little detail can be published. It can, however, be said that the company are one of the world leaders in this field, and have described their ramjet fuel systems as unexcelled.

Notes on the company's history in this field were published in our issue of August 10, 1956. In the past, by far the most important unit has been the Thor, illustrated. Development of this powerplant was effected with a supersonic vehicle named Bobbin, driven by twin Thor engines after initial launching by rocket boost motors. All aspects of Thor's behaviour were proven during numerous test-firings in Australia, and 100-per-cent reliable operation has now been assured. Thor is now in production on a very large scale as the powerplant of the Bristol/Ferranti Bloodhound surface-to-air weapon, chosen by the R.A.F. as the standard anti-aircraft missile for home defence.

D.H. *The de Havilland Engine Company, Ltd., Leavesden Aerodrome, Watford, Herts.* Paradoxically, although official support has for some time been withdrawn from the biggest D.H. engine, the company's overall business prospects are anything but bleak. As a result of extensive and painstaking development de Havilland have prepared a range of powerplants which have gained, or promise to gain, very wide acceptance in existing and projected aircraft and related systems.

Since 1927 de Havilland have been renowned as makers of low-power piston engines under the family name of Gipsy. The latest members of this family remain in production for fixed-wing aircraft and helicopters. Centrifugal turbojets, of which several thousand have been delivered since 1943, are gradually being run down in production, but will continue to be built for a considerable period. The new family of axial engines is progressing favourably and is nearing the production stage; the Gyron Junior, in particular, bids fair to become a unit of the first importance. Rocket motors include the Super Sprite, in full production as an a.t.o. unit, and the highly efficient Spectre.

Ghost and Goblin engines have been widely exported and built abroad, and for some years a technical association has been maintained with G.E. (U.S.A.). Apart from engines the company have developed reverse thrust, flap-blowing and jet-deflection mechanisms and a wide range of shaft-drive units running on high-test peroxide. Sub-contract work is being done for other engine firms.

Headquarters of the Engine Company—which is, of course, one of the many partners in the D.H. Enterprise—is located in a new building on the airfield at Leavesden, near Watford, Herts. Also at Leavesden is the main factory for the production of piston engines, gas turbines and rocket motors, together with the principal overhaul base. At the former H.Q. at Stag Lane, Edgware, Middlesex, is the Engineering Division, responsible for prototype design and research. Chief engine-test centre is the *ad hoc* colony on the north side of the D.H. Aircraft airfield at Hatfield, Herts. Administered by Stag Lane, this facility can test a Gyron Junior at conditions appropriate to Mach 1.25 at sea level, using a Gyron to provide power, and many other facilities are provided in the Halford Laboratory. A Mach 2 tunnel is a particularly valuable tool, especially in view of the company's heavy commitment in the field of supersonic propulsion. At Harlow, Essex, a completely new plant is being established for the design and development of new motors by the Rocket Division. Finally, the London D.O. is handling nuclear projects.

Ghost. All Ghost engines now being built are of the final series 105. Previous marks were described in our "Aero Engines" issues of 1954 and 1956.

Compared with the earlier Ghosts the 105 gives higher performance, by virtue of increased r.p.m. and turbine-inlet temperature. The turbine nozzle guide vanes are hollow and cooled by compressor discharge air, and the turbine rotor has Nimonic 95 blades retained in revised root serrations with pin fixing. Another design change is the adoption of fully floating nozzle boxes downstream of the combustion chambers. The new fuel system is by Lucas, and incorporates a single D-type pump; top-speed control is an electrical system by Lucas-Ultra.

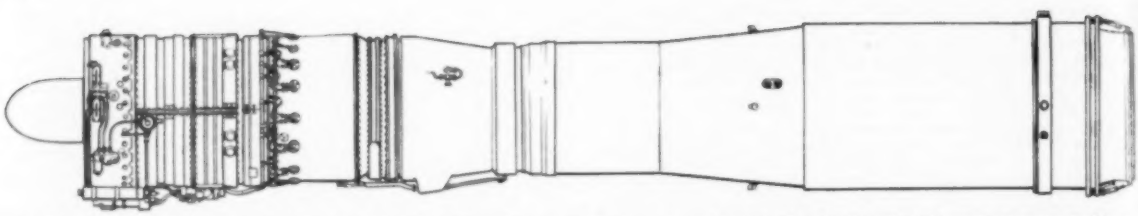
Production units are delivered as Ghost 53 Mk 1s to the Royal Navy. They power the Sea Venom F.A.W. 22, and in due course all Sea Venoms will be retrospectively fitted with the engine.

Goblin. Previously described in this journal, the Goblin centrifugal turbojet remains in production as the powerplant of the Vampire Trainer. Export Vampire T.55s have the Goblin 35, of 3,500 lb thrust. Similar engines are fitted to Vampire Trainers manufactured in Australia and India.

Gyron. Under the direction of the late Maj. Halford the design of this big turbojet started in 1951, with the company designation H.4. For some years previously Maj. Halford, Dr. Moult and their colleagues had been determining the type of gas turbine which would be required for advanced supersonic military aircraft of the period 1955-1965. They concluded that the optimum form of turbojet should have only a moderate pressure ratio, but should operate with the maximum possible mass flow and top temperature and also be capable of association with an advanced afterburner.

Much of the preliminary design work concerned the compressor, and that of the Gyron is of an advanced form. It comprises seven discs and spacer rings, with diameters which rapidly increase from front to rear, through-bolted to each other forming a rigid unit. Steel blades are then fitted to the peripheries of the discs, each blade having a double-lug root which straddles the disc and is retained by a pin. The

The Halford gas-dynamics laboratory of de Havilland Engines is situated on the north side of Hatfield aerodrome. It is capable of conducting full - scale experiments on modern gas-turbine powerplants.



de Havilland Gyron DGy.2. Single-shaft turbojet with afterburner. Seven-stage compressor, annular combustion chamber with 17 burners, two-stage turbine, reheat jet-pipe with two-position nozzle. Maximum height, 55.2in; maximum width, 49.9in; overall length, 349.3in (121.3in without jet-pipe); dry weight, with non-afterburning jet-pipe, 4,270 lb; maximum thrust, 25,000 lb (dry thrust 20,000 lb with s.f.c. of 1.04).

AERO ENGINES 1957 . . .

large magnesium-zirconium intake casting is heated by bleed air and contains an integral oil tank, and the compressor casing is divided both transversely and longitudinally, the rear portions being steel. Through one of the intake struts passes a push/pull rod actuated by a short-stroke ram which, *via* a toothed rack and ring at the rear of the intake casing hub, positions the variable-incidence inlet guide vanes. The latter are moved during starting and acceleration.

An unusual feature of the design is that it has been found possible to dispense with a centre bearing. A roller bearing and double-ball thrust bearing are fitted ahead of the compressor and the two-stage turbine is overhung beyond a large roller bearing. Compressor and turbine are joined by a large-diameter tubular shaft machined from a steel forging; splines at the rear end carry the turbine discs and the shaft increases in diameter towards the front and finally flares out to a flange which is bolted around the periphery of the rear of the compressor itself. Turbine rotor blades are fir-tree mounted. The hollow, air-cooled first-stage stators are axially floating and the second row are pinned at each end.

Of truly annular form, the combustion chamber comprises inner and outer liners each fabricated from Nimonic rings spot-welded together by corrugated spacers to provide film cooling. Two Lucas D-size pumps feed fuel to a flow-distributor on the underside of the engine which meters the fuel to each of the 17 upstream burners. Originally there were conventional double manifolds but it was found that the additional 46in head of fuel on the lower burners caused biased distribution at high-altitudes and low power settings. Both old and new fuel systems are by Lucas. The burners themselves are fed by rigid pipe and each is mounted behind a swirl inducer at the rear of a short duct which extracts a completely distinct flow of primary air from a ram intake at the front of the chamber.

As shown in the diagram, the afterburner is of awesome proportions and terminates in a variable-area clamshell nozzle. Fuel is injected through four concentric rings each immediately upstream of a relatively small vee-gutter flameholder. In fully supersonic installations the propelling nozzle would be of convergent/divergent form and would have multi-flap area variation and probably aerodynamic means for altering throat area. High-intensity reheat systems have been evolved during extended trials with Gyrons and Ghosts, and temperatures can be held at 2,000 deg K. Peak fuel flow for a first-generation afterburning Gyron can reach 12,000 gal/hr, the reheat fuel being fed by an air-turbine-driven pump.

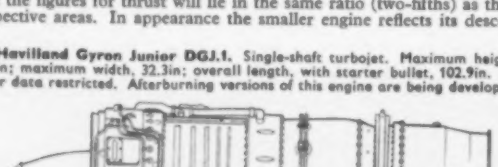
First run of the prototype H.4 engine took place on January 5, 1953. In August 1955 the conservative DGy.1 rating of 15,000 lb dry was established, and this was raised, without materially changing the design, to 20,000 lb dry last February. Flight development began on July 7, 1955, using a Short Sperrin as a test bed. Throughout all its flying the engine has behaved admirably.

The adjective "first-generation" used above implies that a more advanced series of Gyron has been developed. That this is so cannot be confirmed at this stage, but it is self-evident that the Gyron could be persuaded to give far more than 20,000 lb dry thrust. The financial outlay from the M.o.S. contract was curtailed in March of this year, for the simple reason that there was no government-sponsored aeroplane able to take the engine. Its development is at present continuing as a company venture, to meet the needs of several future projects, both at home and abroad.

Gyron Junior. Development of this engine has been hastened by its close similarity to the Gyron, of which it is a two-fifths (area) scale. Since September 1954 it has been a major D.H. programme under contract to the M.o.S.

As it is still very active no details of its interior or of its performance may be published; it is, however, fair to assume that the first-generation Junior will not differ greatly from the early Gyrons, and that the figures for thrust will lie in the same ratio (two-fifths) as their respective areas. In appearance the smaller engine reflects its descent from the Gyron, and differs mainly in having a two-piece compressor casing and a relatively longer combustion chamber fed with fuel by a Dowty Spill-flow system. There is also a variant with afterburner, suitable for a supersonic application such as that depicted by D.H. Engines in a hypothetical intercepter.

de Havilland Gyron Junior DGJ.1. Single-shaft turbojet. Maximum height, 41.1in; maximum width, 32.3in; overall length, with starter bullet, 102.9in. All other data restricted. Afterburning versions of this engine are being developed.



Less than a year from the first issue of drawings, the prototype ran in August 1955. Development has been most successful and has ranged over a wide variety of fields other than those concerned with perfecting the basic engine. First flight took place in May of this year, with a single Junior mounted in a Canberra. Late in the year flight-trials are to begin with two Juniors with reheat fitted to a Javelin, which is being converted by the Napier Flight Development Establishment at Luton.

No details can be given of the applications of the engine, but it has been reported to be the powerplant of the Blackburn B.103 (N.A.39) strike aeroplane for the Royal Navy and of the definitive Saro mixed-power intercepter, described in one journal as the P.177.

Gipsy Queen. As in previous years, the principal variants of this family of inverted six-in-line air-cooled engines are the Queen 70 and Queen 30. For the Dove the standard powerplant has been the Queen 70/4, a supercharged, geared, direct-injection engine rated at 340 h.p. In current production Doves and Devons, and available for retroactive fitting to existing Doves after a spar-modification, the up-rated 70 Mk 2 is rated at 380 h.p.

Supercharged but ungeared, and fitted with a float-type carburettor, the Queen 30 Mk 2 powers the Heron. Unlike the Dove engine, which is installed as an engine-change unit, the Queen 30 is supplied as a bare engine. In late-model Herons it is often associated with a feathering propeller; the Dove propeller has three blades and is both feathering and reversing.

Gipsy Major. One of the most important of the range of four-cylinder Gipsies is the new Major 215, powerplant of the Skeeter helicopter. A logical development of the basic 200-series—which are distinguished from other Gipsy Majors by their direct fuel-injection and greater capacity—the 215 runs at higher maximum r.p.m. and so gives 15 additional horse-power. Moreover, since its chief application concerns a helicopter, it has been designed to hold this power for one hour.

It introduces a new eight-stud fixing for the cylinders and heads which will be standard on all future Gipsy engines. Each cylinder is fed with fuel from an S.U. injection pump mounted at the bottom of the wheelcase and driven *via* the oil pump. In the Skeeter a max-r.p.m. governor is fitted, for use when the rotor is declutched, and equipment includes a cartridge starter and all normal accessories.

An exhaust-driven turbo-supercharger is under development for the Major 215, with which the full-throttle power of 215 b.h.p. will be maintained up to 4,000ft and I.C.A.N. +30 deg C. At sea level, temperate, 222 h.p. will be available. Until the turbo supercharger is available water-injection will be fitted for restoring full power up to I.C.A.N. +30 deg C.

Super Sprite. Developed from the earlier Sprite "cold" peroxide motor, the Super Sprite was the first rocket motor to run on H.T.P. (high-test peroxide) and kerosine as a "hot" motor, using silver-plated nickel gauze as a solid, non-consumable catalyst. It was also the first —and is still the only—British liquid-propellant motor to go into production.

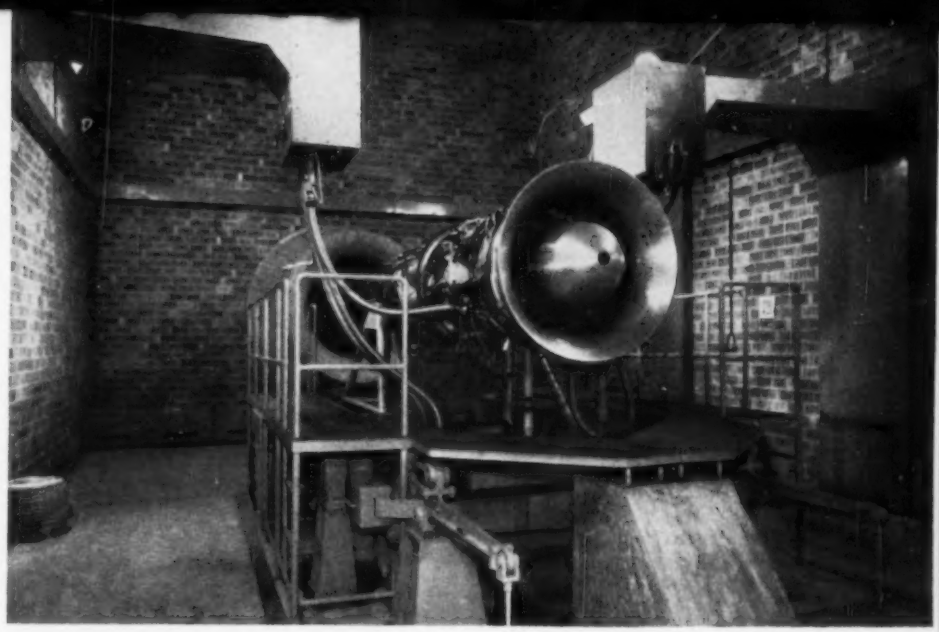
Its sole application is the provision of extra take-off thrust for the Valiant medium bomber. The Super Sprite is made up into a jettisonable and recoverable self-contained pack, complete with tanks, in a monocoque nacelle equipped with mounting lugs for location under the Valiant wing, a stabilizing mechanism of tape and stub wings, a drogue and parachute system and inflatable bags to absorb the shock of landing.

Spectre. Unfortunately no details of this unit may be published, beyond the following facts: the name covers a whole family of units, of which some members are for a.t.o. use and others for prime propulsion; the propellants are H.T.P. and kerosine; the thrust is variable over a wide range; the feed is by turbopump; and the design is more advanced than that of the Super Sprite.

Only announced application for a Spectre is as the powerplant of the S.R.53 mixed-power intercepter. By inference one can assume that this version of the Spectre might well have the same thrust as that of the Screamer motor, intended for the other aircraft to the same specification, the Avro 720. The Screamer thrust is 8,000 lb. Another possible application might concern the provision of a.t.o. thrust for the Victor or Vulcan, or both, since this would be a logical development from the Super Sprite in the Valiant.

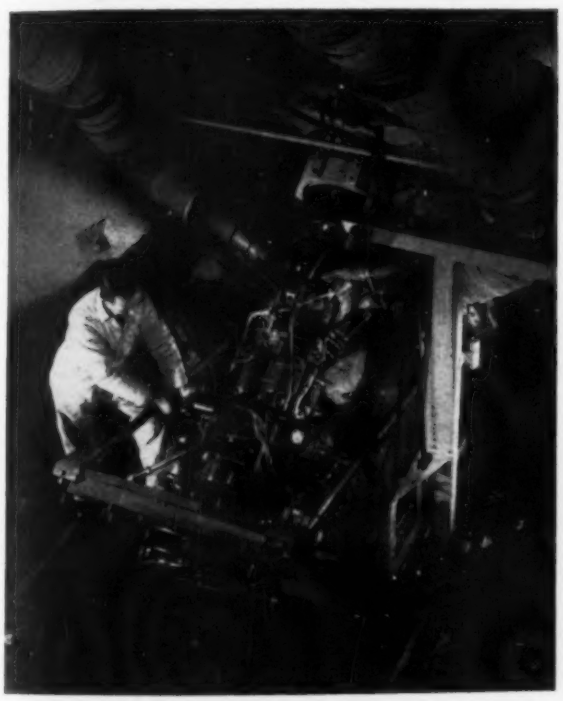
Full thrust with a development unit was achieved in July 1954. In July 1956 a later unit received special-category flight-clearance. Flight development of a Spectre mounted in a Canberra began in December, and a second Canberra should soon accelerate the work. Many test-cells at Hatfield are engaged upon Spectre firing.

(*Continued on page* 118)



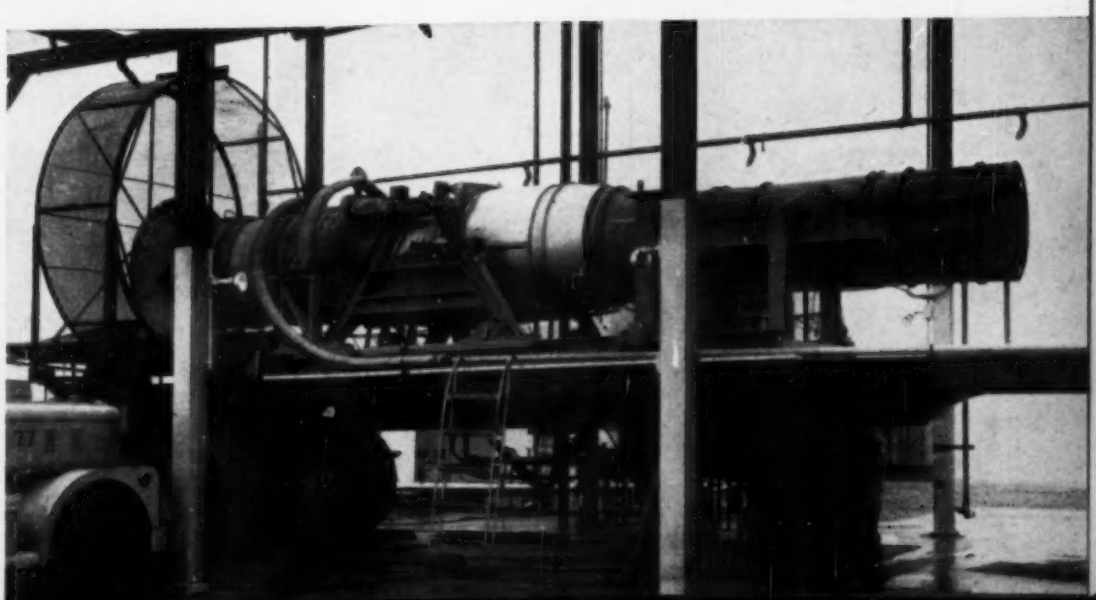
ITALY: One of Fiat's new turbojet test-cells at Lingotto, showing a General Electric J47-GE-33 on reheat trials before delivery to the U.S. Air Force.

GREAT BRITAIN: Napier's Gazelle free-turbine engine for the Wessex recently completed three consecutive rehearsal type-tests to the new—and more arduous—150-hr schedule (p.118).



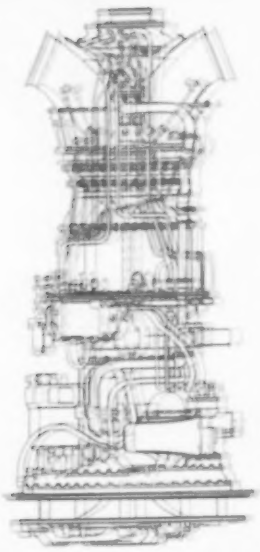
1957 ENGINES ON TEST IN FOUR COUNTRIES

FRANCE: A production Atar E-series turbojet on its way to one of the many test-beds at the S.N.E.C.M.A. establishment at Melun-Villaroche.



U.S.A.: Demonstrated at Quehanna, Pennsylvania, two months ago, this engine is the precursor of the quiet, efficient, cool-running Zephyr, developed jointly by Bristol Aero-Engines and Curtiss-Wright.

AERO ENGINES 1957 . . . . .



Napier Gazelle NGa.13. Free-turbine shaft-drive helicopter engine. Eleven-stage compressor, six interconnected combustion chambers, two-stage compressor turbine and single-stage power turbine. Overall diameter (intake casing), 33.5in; overall height, 70in; equipped dry weight, 665 lb; maximum rating, 1,600 s.h.p. (5-min limit) at 20,400 compressor r.p.m. with s.f.c. of 0.564 or 1,450 s.h.p. (one-hour) at 19,500 compressor r.p.m. with s.f.c. of 0.573. Note: this engine can be mounted at any angle and is shown in the vertical position.

NAPIER. *D. Napier and Son, Ltd., The Vale, Acton, London, W.3.* Since our last aero-engine review the operations of this company have become more equally divided among a diverse range of powerplants. Although still a major programme, the Eland turboprop is now being rivalled in development effort by the smaller Gazelle free-turbine unit, and also by a range of rocket motors about which little may be said. Napier are also, of course, active in non-aeronautical fields, particularly in the development of advanced diesel engines and turbo-blowers for marine and industrial use.

After having been a leading piston-engine firm for many years, Napier—who are members of the English Electric Group—started gas-turbine development in 1947 with a 4-shaft axial turboprop named Naiad. At the same time design was under way on the most economical aircraft powerplant yet built, the Nomad combined diesel/turboprop unit. Neither found a production application, nor did the otherwise extremely successful Oryx, a gas-generator developed for helicopter tip-drive applications. Greater commercial success has been achieved by the Eland and Gazelle described below.

Gas-turbine development is undertaken at the Acton factory and design office and at test-beds at Park Royal. Production is the responsibility of a large plant at Netherton, Liverpool, where many 100-series Rolls-Royce Avons were manufactured in recent years. At Luton, design and development staffs are working on ramjets and rocket motors. Also at Luton, the Flight Development Establishment, in addition to undertaking test flying, is a major sub-contractor on special aircraft conversion work.

Eland. Originally intended solely as the most attractive 3,000-e.h.p. turboprop which the company could conceive, the Eland is now a family of related engines intended for the propulsion of both fixed-wing aircraft and advanced helicopters. All Elands have similar basic power sections. By employing a very efficient compressor Napier have obtained reasonable pressure ratio from a short, single spool without incurring penalties in handling; rotor blading is of aluminium bronze and variable inlet guide vanes are fitted. The whole engine can be readily disassembled into major units (such as the reduction gear, compressor, combustion section or turbines) and major loads are transmitted through an external tubular framework to maintain rigidity. Top-temperature control is by a mercury vapour system, the self-centring reduction gear contains an integral hydraulic torquemeter and the magnesium intake casting is anticed by pods which also serve as the oil coolers. Accessories are driven by a train of gears from the front of the engine and lie within the diameter established by the intake thus allowing the engine to fit a 36in cowling, should this be required.

"Fixed-wing" Elands have ranged over a variety of ratings, from 2,590 up to almost 4,590 h.p. with coiled blades. The bulk of the running is concentrated on the 3,500 h.p. NBL.6 which is probably best-suited to such tasks as re-engining the numerous Douglas and Convair transports which are at present powered with the R-2800 and related units. Flight development of fixed-wing Elands has been conducted with a Vanguard, an Ambassador and a CV-340, and the fleet will soon be augmented by the addition of a new CV-440 which Napier recently purchased. For many months negotiations have been in progress with several operators with a view to selling the Eland as a replacement unit for a range of piston engines. The potential market in such operations could easily exceed 2,000 engines in a relatively short time. Napier are developing conversion packages with which the change can be effected in the field.

Napier do not intend to manufacture complete cowlings or airframe-conversion parts. Eland purchasers in the Americas will receive kits through Pac-Aero, Napier's licensee for the Spraymat de-icing system. Napier's CV-340 is being prepared to go to the U.S.A. early in October in order to complete C.A.A. trials and undertake demonstrations. The CV-440 is being fitted with Elands in America, and should continue the development flying at Luton about next February.

Of the "rotary-wing" Elands the more orthodox is the series 209 (Napier designation) for the Westland Westminster. Basically this engine comprises a NBL6 with the gearbox mounted at the rear end, aft of an exhaust annulus and outlet trunk. A direct shaft-drive is taken to the rotor through a large gearbox provided with free-wheels to permit single-engine operation.

Of unique conception, the E.151 (NBL3 rating) has been prepared to power the Fairey Rotodyne. It consists of a basic turboprop Eland fitted with split exhaust trunks and a main-shaft extended to the rear behind the turbine to a hydraulic coupling. For take-off, this coupling is filled with oil and transmits the drive to a six-stage auxiliary compressor which feeds plain air to combustion pressure-jets at the tips of the rotor blades, the propellers remaining in minimum (no-thrust) pitch. For cruising, the auxiliary compressor is de-clutched and all power is absorbed by the propellers. Both the powerplant and its control system are now ready for flight trials, which should begin very shortly.

Gazelle. Fully described in our issue of May 10 last, the Gazelle has developed as an omni-angle free-turbine unit for helicopter propulsion; fixed wing engines of the same family are also in hand. For many months the Gazelle has been Napier's principal engine for military production and it fills a most important part of the British powerplant spectrum.

As the drawing shows, air is taken in around the periphery of a large inward-radial intake casting, which also houses gear-trains and carries the bulk of the accessories on its upper face. Developed jointly with Lucas, the combustion system retains the upstream-injection of earlier Napier engines, but marks a departure in that the configuration is virtually of the can-annular type. Furthermore, as the ability to remove individual flame-tubes is not the great advantage it was once believed, the casing is stressed to carry engine loads and external tubular framework has been eliminated.

At present the helicopter Gazelle has two major applications. The NGa.13 is the powerplant of the Westland Wessex anti-submarine helicopter of the Royal Navy. The rating is that of the NGa.3, and the additional numeral in front of the figure 3 indicates that the engine output-shaft turns in a direction contrary to that of the original Gazelle, this change having been accomplished merely by providing "mirror-image" blading on the power turbine. On May 17 the first Wessex (actually a converted Sikorsky S-58) began its flight trials, and remained in the air for more than an hour despite the fact that its engine had not previously been airborne. The same type of Gazelle was recently removed from a Napier test-bed after having completed some 560 hr of running, including three complete 150-hr rehearsal type-tests based on the new M.o.S. schedule (which includes 50 hr at maximum rating and no fewer than 300 accelerations).

A related engine is the NGa.2, which will power the Bristol 192 multi-purpose helicopter of the R.A.F. As this is a twin-engined aircraft, single-engine operation is enhanced by the provision of an emergency rating of 1,650 s.h.p. The NGa.2s are installed in the Bristol helicopter directly beneath each rotor, in a substantially vertical position.

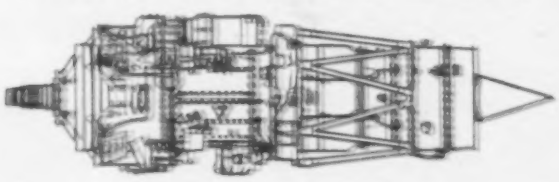
Ramjets. For several years Napier have been conducting ramjet development work for the Ministry of Supply. As sub-contractors to the National Gas Turbine Establishment the company designed, developed and tested a series of test vehicles powered by integral ramjets of some 18in diameter. This work was described in our issue of August 10, 1956. No information may be published on the company's current operations in this field.

Rocket Motors. A variety of liquid-propellant motors for test vehicles and missiles has been developed, and in our issue of September 14 last we published a photograph of a batch of production NRE.11 motors awaiting shipment to the missile test establishment at Woomera. A later design is the NRE.17, which is later and more compact and exceptionally easy to mass-produce.

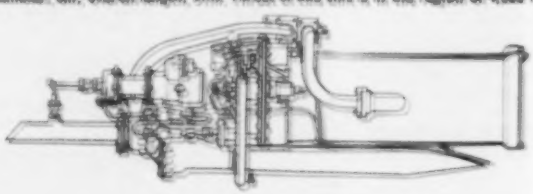
An accompanying drawing depicts a more complicated rocket engine typical of those which the company is now developing for piloted aircraft. Fed with H.T.P. and kerosine by turbopump unit, this motor has a single chamber and is probably rated at about 4,000 lb-thrust at sea level. It is intended to typify current Napier thinking in this field and should not be construed as being directly related to the engine announced as the Scorpion. A twin-barrel version of the latter has for a year been on flight-test in a Canberra and is at present in North Africa undergoing tropical trials.

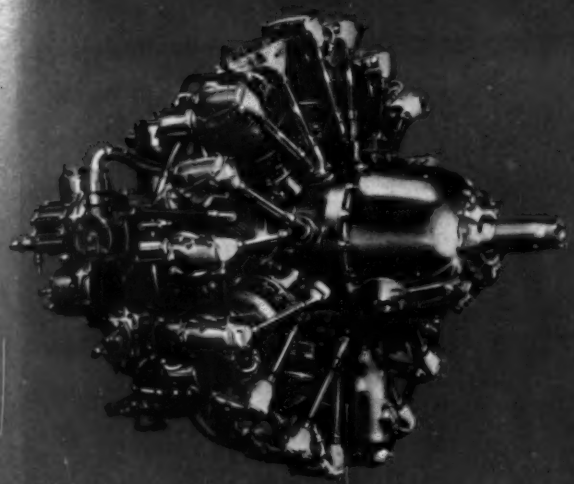
Napier have also developed a range of small H.T.P. rocket-boost units for helicopter tip-drive applications. Most of the development flying has so far been carried out with units matched to the Saro Skeeter light helicopter, but systems suitable for larger helicopters—such as the Sikorsky S-55—are in active development. The Skeeter installation was fully described in our issue of January 18 last.

Napier Eland NEL6. Single-shaft turboprop. Ten-stage compressor, six combustion chambers and three-stage turbine. Overall diameter, 36in; length, 120in; equipped dry weight, 1,735 lb; mass flow, 31 lb/sec; pressure ratio, 7:1; maximum rating, 3,500 e.s.h.p. (3,150 s.h.p.) at 12,500 r.p.m. with s.f.c. of 0.595.



Napier Rocket Engine (see text). Pump-fed single-chamber rocket for piloted aircraft operating on H.T.P. and kerosine. Maximum diameter, 18in; chamber diameter, 8in; over-all length, 33in. Thrust of this unit is in the region of 4,000 lb.





Alvis Leonides engines in the Hunting Percival Pembroke contributed much to the successful choice of this dependable aircraft.

Ordered in quantity for the WEST GERMAN AIR FORCE

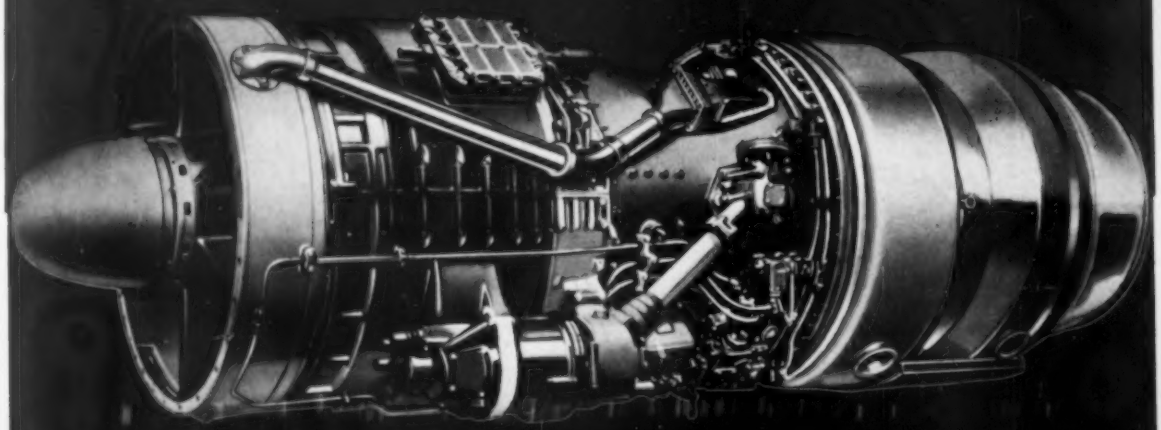
Powered by Alvis Leonides engines the versatile Bristol Sycamore helicopters will be in use in all three German services.

ALVIS **LEONIDES** Aero Engines

ALVIS LIMITED COVENTRY ENGLAND

I.C.I. Titanium

is being used in



Rolls-Royce

Avon Engines

ICI

IMPERIAL CHEMICAL INDUSTRIES LIMITED, LONDON, S.W.1

A SEVEN-JET B-47?

In this case, yes. The seventh jet, in the rear fuselage pod-mounting shown above, will be Orenda's Iroquois, designed for supersonic speeds.

The Boeing B-47 is on loan from the United States Air Force for flight testing the Iroquois in the initial subsonic phases.

ORENDA
ENGINES LIMITED
MALTON, CANADA

MEMBER A. V. ROE CANADA LIMITED & THE HAWKER SIDDELEY GROUP

Halo complex phenomena in the skyways of tomorrow

Less than 40 years ago Alcock and Brown pioneered transatlantic flight. This year 1957, a million passengers will fly the Atlantic. Tomorrow, very soon now, we shall be flying in the stratosphere at supersonic speeds.

Above the turbulence of the troposphere, the air temperature will have dropped to 70°F below zero, and with no particles to reflect the sun's light, the sky will be quite black.

Coming down from the stratosphere passengers may see halo complex phenomena, such as the rare cruciform mock lunar ring, 180° in azimuth from the moon, produced by ice particles in suspension in the lower atmosphere. But they will feel nothing of the extremes of temperature and pressure that will affect their aircraft.

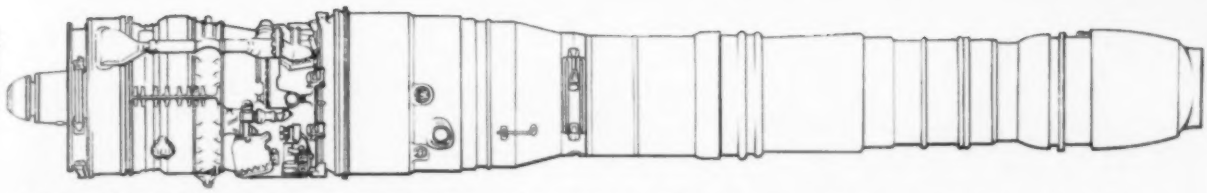
Streaking through the stratosphere these great passenger aircraft will use powerful ram jet motors and special petroleum products— products which even now are being evolved by Esso Research, to meet the extremes of temperature that range between the troposphere and the stratosphere.

ESSO

Flight in the 21st century

is already the concern of Esso technologists

ESSO PETROLEUM COMPANY LIMITED. 36 QUEEN ANNE'S GATE, LONDON, S.W.1 AVIATION TECHNICAL SERVICE. RELIANCE 1261



Rolls-Royce Avon RA.24R. Single-shaft turbojet with afterburner. Multi-stage compressor (15 stages in the related RA.28), can-annular combustion chamber with eight burners, two-stage turbine, reheat jet-pipe and two-position nozzle. Overall diameter, 41.5in; overall length, as illustrated, approximately 299in; maximum dry thrust, without reheat, 11,250 lb. All other data on this engine are restricted. Note: the length of reheat jet-pipe shown is probably longer than the optimum.

AERO ENGINES 1957 . . .

ROLLS-ROYCE. *Rolls-Royce, Ltd., Derby.* The design and manufacture of aero engines is by far the most important of the diverse activities of this great and famous company. Easily the largest aircraft-propulsion firm outside the U.S.A., Rolls-Royce are actually comparable with the largest such firms across the Atlantic both in personnel (42,000) and in volume of business; and in their ability to produce gas-turbine aero engines they need acknowledge no master, and possibly no equal.

During the past year Lord Hives has stepped down from the leadership of the company, and the resulting appointments include those of Lord Kindersley as chairman and Mr. J. D. Pearson as chief executive, deputy chairman and managing director of the Aero Engine Division. A logical move—in view of the changing pattern of the aircraft industry—is the agreement, reached last month, to increase the authorized share capital from £10m to £20m.

Headquarters of the company is at Nightingale Road, Derby, and several other departments, as well as the main aero-engine production unit, are also in this city. Other plants devoted to the production or service-support of aero engines are the Scottish Group of factories at East Kilbride, Hillington and Blantyre. At Mountsorrel, Leics, is a sheet-metal plant, and machine-tool overhaul is the responsibility of a facility at Larkhall. Gas-turbine development is centred at Barnoldswick, Lancs, and the main experimental and test-bed site is on Sinfin Moor, Derby. Across the road from the latter establishment is a large factory which, when the Oil Engine Division vacate it in order to concentrate their operations in Shrewsbury, will be occupied by the Aero Engine Division for a purpose as yet unstated.

A 13½-acre extension to the Sinfin plot is now occupied by a test facility capable of handling "the most advanced air-breathing engines projected" at speeds up to 1,500 m.p.h. at simulated altitudes of 70,000ft. The new facility will cost considerably more than the £3.28m originally quoted; like all Rolls-Royce research and development assets it will be entirely the property of the company. Another important research site is that at Spadeadam, commented upon below under "Rocket Motors." At Old Hall, Derby, is yet another research establishment, referred to in the section "Nuclear Power."

At present Rolls-Royce hold a unique position in the field of the propulsion of gas-turbine commercial aircraft. Production contracts are held for two types of turboprop, an advanced turbojet and an even more advanced by-pass turbojet, all of which are to be in route-operation within two years. Statistics indicate that the first commercial turboprop, the Dart, has now established itself as the world's most reliable aero-engine, and it is showing the company various methods by which the overhaul life of commercial turbines can be extended beyond anything possible with piston engines.

Rolls-Royce have hinted that their future plans are linked firmly with the two-spool by-pass engine. In the recent Chairman's Statement was the passage "the requirements for shorter distances and higher traffic densities . . . are included in our future development programmes."

Avon. In 1946 the AJ.65 engine was projected as an axial unit of 6,500 lb-thrust capable of "taking over where the Nene left off." This unit finally evolved into what has become known as the first-generation Avon, installationally referred to as the 100-series.

Features of these engines—which were fully described in our issue of December 16, 1955—include a compressor built up on a stepped-diameter tubular shaft and with handling qualities improved by variable-incidence inlet guide vanes and lift-type blow-off valves, together with hot-air anticing, provision for tapping considerable quantities of compressor-delivery air, a shaft-drive to a remote gearbox and some of the world's first mass-produced high-pressure fuel/oil heat exchangers and turbo-starters.

To meet the huge demand for the 100-series Avon large numbers were built by Bristol, Napier and Standard Motors, and major extensions were made to the Rolls-Royce Scottish plants to accelerate output. The engine entered R.A.F. service early in 1951 with the Canberra, and several thousand 100-series units are now flying in this aircraft, the Hunter and other types. A related unit is the transport series 503, or RA.25, which powers the R.A.F. Comet 2. First-generation engines are being made in Australia (*q.v.*) and have been built in Sweden and Belgium (*q.v.*). Typical of this family is the RA.21, of 8,050 lb-thrust. Engines of this general nature have been largely responsible for the Avon flight-time of well over one million hours—most of it in short sorties.

By 1951 a succession of advanced projects led to an engine which, although virtually completely new, retained the name of Avon and started the second generation with series numbers beginning at 200. These later Avons give from 25 to 35 per cent more thrust than the 100 series and have appreciably lower consumption for any given top temperature. Basic features of the new Avons—previously unpublishable—include 15 stages of compression in a single axial spool built up in a manner similar to that of the earlier engines, variable inlet guide vanes and a large sliding blow-off gate valve, a can-annular combustion chamber housing eight flame tubes and a two-stage turbine with extended-root blades. At least some of the 200-series engines have cooled turbine blades, a feature which is now being incorporated in the company's civil engines.

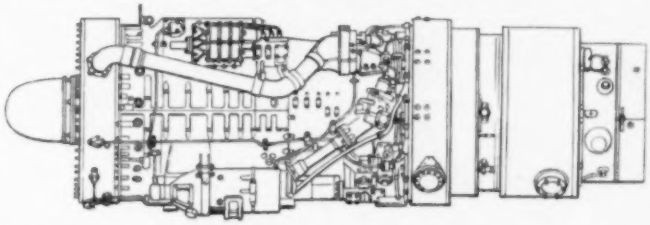
Two of the most important are those depicted in the diagrams. The RA.24R is the most powerful Avon to have reached the operational stage and it typifies the latest military engines; one can probably assume that engines of the type illustrated may power the P.1B fighter. Advanced high-power Avons are also used in the Sea Vixen and the blown-flap Scimitar. Earlier military Avons of the 200 series, and generally with ratings in the 10,000 lb bracket, are now in large-scale service in Hunters and Valiants, and are also used in the P.R.9 Canberra. Engines of the same family are in production in Sweden and Belgium, and a licence-to-build was obtained by Hispano-Suiza in France. An unusual application of such an engine is found in the Ryan X-13 tail-sitting VTOL prototype of the U.S.A.F., in which completely reliable operation was the over-riding requirement.

Most advanced of the current Avons is the highly efficient RA.29, which is being intensively developed as the first series of Rolls-Royce commercial turbojet. In its present development stage it is already the most efficient single-shaft engine in the world from the viewpoint of specific consumption, which more than counteracts its slight weight disadvantage in comparison with the General Electric CJ-805. Moreover it is certain to reach a very high overhaul time relatively rapidly; the longest-life turbine blades in the world are those of the Dart, and the RA.29 turbine runs some 100 deg C cooler. It is unfortunate that full performance figures or curves may not yet be published, since the zero-stage on the compressor and the new three-stage turbine combine to give outstanding economy.

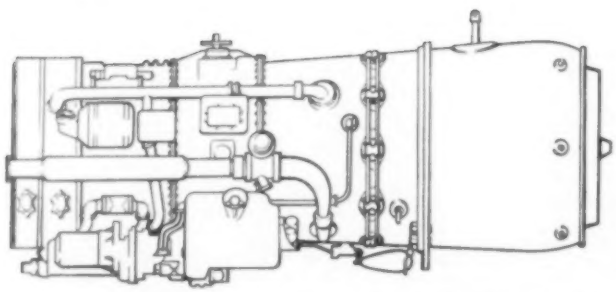
Flight development of the RA.29 began in August 1956, using a Canberra test-bed. Icing trials are taking place with a nacelle under an Ashton, and endurance trials are being flown on scheduled services with two Comet 2Es, each of which has a pair of RA.29s in the outboard positions. Four of the new engines are flying in the Comet "3½A." Noise-suppression has led to the evolution of a series of very effective nozzles, and reverse-thrust has been completely finalized during 1,000 hours of running and over 200 landings with the reversing Hunter.

First deliveries to airlines will be made next year, in respect of both the Comet 4 and the Caravelle. The latter aircraft has the Avon 522, weighing 3,348 lb and fitting a 50in envelope diameter complete with auxiliaries and gearbox drive. The engine illustrated powers the Comet 4, and the Comet 4A will have the Avon 525, weighing 3,365 lb. Later RA.29s may well find several other applications. The engine has passed its 150-hr type-test to both A.R.B. and C.A.A. schedules.

Rolls-Royce Avon 524 (RA.29 rating). Single-shaft turbojet. Sixteen-stage compressor, can-annular combustion chamber with eight fuel injectors and three-stage turbine. Overall diameter, 41.5in (carcase diameter, 36in); overall length, as illustrated, 124.8in; dry weight, 3,326 lb; maximum thrust, 10,500 lb at 8,000 r.p.m. with s.f.c. of 0.775. All other data restricted.



Since 1951 the Rolls-Royce Avon has been the British engine manufactured in the greatest quantity. It powers many types of military and civil aircraft. These are 200-series Avons for military applications.



Rolls-Royce Conway 505 (RCo.10 rating). Two-spool by-pass turbojet for commercial transports. Multi-stage low-pressure compressor, flow-divider, multi-stage high-pressure compressor of smaller diameter, annular combustion chamber with ten Duplex burners, independent high-pressure and low-pressure turbines and inner and outer jet-pipes. Overall carcase diameter, 42in; overall length as depicted, 132.45in; maximum thrust, 16,500 lb. All other data restricted.

AERO ENGINES 1957 . . .

Conway. The theory of by-pass engines has been explained often enough to need no repetition. This type of powerplant was worked out on paper in 1946 by Dr. Griffith, Rolls-Royce chief development engineer; a project study followed in 1950 and the first engine ran in 1952. The thrust progressed from the 9,000-lb level of the RCo.1 to the 13,000-lb rating of the RCo.5, at which point a full type-test was completed in the summer of 1955 at a specific consumption "lower than that for any other type-tested turbojet."

Cancellation of the Vickers 1000-series transports, the engine's only application at that time, brought the Conway programme to a low ebb. Shortly thereafter, however, it became apparent that the Conway could be re-engineered to give very much greater thrust, and that advanced by-pass units would be admirably suited to the big American transports then well advanced in design. The Ministry of Supply placed a development contract for the ambitious ratings of the RCo.10 and 11, and in May 1956 Rolls-Royce were officially advised that a production order for the RCo.11 military engine would be placed. With this notification came an authorization to proceed on tooling, and the new Conway is now in production for the Victor B.2 bomber, at a rating of 17,250 lb dry.

Illustrated here—for the first time—the RCo.10 commercial engine is substantially similar to the military unit but has an appreciably more conservative rating. Turbine-inlet temperature is nevertheless likely to be quite high, and cooled blading is probably fitted; such blading is certain to be used in the military engine. Superficial inspection of the new Conways reveals a change in by-pass ratio from that of the RCo.5, and the overall mass flow has clearly been raised to a very high level without any increase in engine diameter. The intake hub/tip ratio, and the length of the first-stage blades on the low-pressure compressor, must be exceptional.

Flight development of earlier Conways has been in progress since the summer of 1955, with a nacelle mounted under an Ashton. The new series of by-pass engines will soon be seen mounted as the main powerplants of a high-performance aircraft. Civil Conways of the 505 series are due for delivery to airframe manufacturers for certification purposes next summer. Noise-suppression and thrust-reverse mechanisms have been taken to an advanced stage of development, and have already met airframe company's requirements in effectiveness without incurring any significant penalty in weight or loss in normal thrust.

Apart from the order for the RCo.11, which must be substantial, the largest order for the new Conways is that placed by B.O.A.C. for the propulsion of 35 Vickers-Armstrongs VC-10 four-engined transports. Well before this order has to be met deliveries will be in hand on Conway 505s for the Boeing 707/420 for B.O.A.C., Lufthansa and Air India, and on Conway 507s for the DC-8 for T.C.A. For the American aircraft, Rolls-Royce are to deliver complete powerplants, including all accessories, reverse-thrust nozzle, nacelle equipment and the nacelles themselves.

Derwent. Nearly 10,000 of these centrifugal turbojets were made by Rolls-Royce before production ceased early in 1955. Spares-production is therefore a major item.

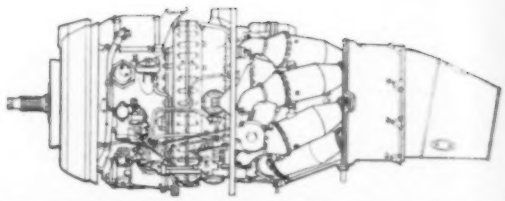
Nene. Series 103 engines, of the 5,400-lb RN.6 rating, are still being made at Derby, for the Sea Hawk F.B.6 (R.N.) and Mk 100/101 (German Navy).

Soar. This lightweight turbojet has now been superseded by later developments. It is referred to in the U.S.A. section as the Westinghouse J81.

R.B.108. Somewhat larger than the Soar the R.B.108—it is as yet unnamed—is a simple, lightweight turbojet of high specific thrust. Five R.B.108s power the Short S.C.1 research aircraft, four being used for lift and one for propulsion.

Dart. Not only is the Dart the only gas-turbine to have built up a long record of scheduled airline service but it is also extraordinarily trouble-free and reliable. The achieved life of the engine is far greater than that of any other gas-turbine, and rivals that of the best piston engines, after having been in service for no more than four years.

As the powerplant of the Viscount, well over one thousand Darts have now been delivered to operators of that aircraft. These engines are all of the 506 series (1,400 s.h.p. or 1,547 e.h.p.) or the 510 series (1,600 s.h.p. or 1,742 e.h.p.). Together, the 506 and 510 have flown roughly 2,750,000 hr and are adding to this total at the rate of over 100,000 hr each month. Indicative of the quality of the Dart is an early B.E.A. 506 engine which recently stripped perfectly after 5,450 hr (probably a record time for any aircraft gas-turbine in the world), during which time it had five overhauls. One set of cans was recently released for 1,500 hr after having already logged 2,000 hr. Even in the arduous service of Capital Airlines (U.S.A.) the Dart 510 has an established overhaul life of 1,500 hr, a figure which applies to every part of the engine.



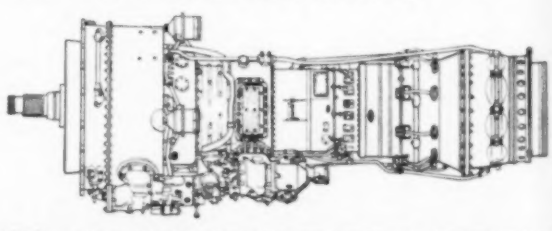
Rolls-Royce Dart 528 (RDa.7/1). Single-shaft turboprop. Two centrifugal compressors in series, seven canted combustion chambers and a three-stage turbine. Overall diameter, 38in; length, 98in; dry weight, about 1,250 lb; mass flow approximately 22 lb/sec; pressure ratio, 5.75:1; maximum rating, 1,890 e.h.p. (1,700 s.h.p.) at 15,000 r.p.m.; typical cruising output at 20,000ft at 300 kt, 1,145 e.h.p. (1,075 s.h.p.) at 13,400 r.p.m. with s.f.c. of 0.6.

Now about to be released for operations is the engine depicted in the drawing. All engines in the 520/RDa.7 family have a new turbine with three stages of shrouded blades, as well as other changes to allow an increased mass flow with auto top-temperature control. First of the new series, the Dart 520 is about to fly in the V.806 and has the same reduction gear as the Dart 510. Initially the cruise rating will be that quoted in the data, but by 1958 the cruise r.p.m. will be raised to 14,000 to give the same output as the later Dart 525. The latter engine is for the V.810D series Viscount, and will become available early next year. Originally known by its rating of RDa.7/2 it is, like all succeeding Viscount engines, limited to 1,800 s.h.p. This power is obtained at 15,000 r.p.m. and gives 1,992 e.h.p. at an s.f.c. of 0.68; cruise rating at 300 kt at 20,000ft is 1,227 s.h.p. (1,325 e.h.p.) with an s.f.c. of 0.57.

In other applications the RDa.7/2 rating can give greater shaft-power. In the A.W.650 the Dart 526 will give 1,910 s.h.p. or 2,100 e.h.p., with an s.f.c. of 0.665, and similar engines fit such aircraft as the F.27 Friendship, Douglas 1906/1940, Stroukoff 134 and Grumman 159. The Dart 527 for the Herald has a cruise-rating, at 275 kt at 15,000ft, of 1,235 s.h.p. or 1,335 e.h.p. at 13,800 r.p.m., with an s.f.c. of 0.615. An offshoot of this family is the only military Dart, the Mk 21 which powers the Bréguet Alize. Specially prepared to suit carrier-based A.S.W. operations, the Dart 21 has a three-stage turbine matched with a Dart-510 compressor. It has a 0.107:1 reduction gear to an 11ft 6in propeller and gives 1,950 s.h.p.

Airline operations with the Dart 520 should start late this year. The immediate target is to establish a life of 1,000 hr, and this should be achieved after about 20 engines have been "pulled." A life of 1,500 hr may be expected within the following 12 months.

Final Dart development will be the RDa.11 series, of which the first variant will be the Dart 545 of the Viscount V.840. Chief differences will be a larger, shrouded impeller to handle a yet greater mass flow, air-cooled blading in the first turbine stage and a reduction gear of increased capacity to handle the greater power of well over 2,000 s.h.p. Engines incorporating all the new features of RDa.11 have been run at full RDa.11 powers during extensive bench testing.



Rolls-Royce Tyne (RTy.2 rating). Two-spool turboprop. Multi-stage low-pressure compressor, multi-stage high-pressure compressor, can-annular combustion system, single-stage high-pressure turbine and three-stage low-pressure turbine driving l-p. compressor and propeller. Overall diameter, 40.5in; overall length, 100.25in; dry weight, approximately 2,000 lb with full equipment; mass flow, 46 lb/sec; pressure ratio, 13:1; maximum rating, 5,315 e.h.p. (4,810 s.h.p.) at 15,250 l-p. r.p.m.

Tyne. At the beginning of the present decade the first schemes for this engine lay in the 2,500 h.p. class, but the Tyne today is twice as powerful. It is fair to describe it as the most advanced and attractive engine with a full-throttle rating of around 5,000 h.p. anywhere in the world.

Two-spool compression achieves a pressure ratio of 13:1 and, by operating at high r.p.m. and velocity, handles a high mass flow within a very diminutive bulk. High-intensity combustion takes place in a can-annular chamber which follows advanced design practice and is very easily accessible. Throughout the engine can be found features stemming from the airline experience of the Dart.

First bench-run took place on April 23, 1955, and flight development began in June 1956 with a Tyne mounted in the nose of a Lincoln. Two later powerplants for flight development are about to be installed in an Ambassador. The drawing depicts a re-engineered development Tyne, due for delivery next summer as the powerplant of the V.951 and V.952 Vanguards. Other possible applications include the Beverley, the A.W.651 and the DC-7T/DC-10.

Development running is now taking place at powers well in excess of those of Stage I. By 1961 the Tyne II should be in service at a rating of 4,810 s.h.p. or 5,315 e.h.p. Two years later the Stage III is to give 5,235 s.h.p. or 5,760 e.h.p. All these powers will be achieved with an economy which can confidently be predicted as distinctly better than that of the most efficient piston engine.

Piston Engines. Manufacture of the last batches of 2,455 h.p. Griffon 57s is now in hand at Hillington. Derby built its last piston engine, also a Griffon 57, in December 1955. In recent years several hundred Merlins have been exported to C.A.S.A. in Spain, and spares are being made for some 20,000 engines—the vast majority Merlins—still in service in various parts of the world.

Rocket Motors. Early in 1955 a licence was obtained for the manufacture of rocket motors incorporating features developed by the Rocketdyne Division of North American Aviation. The American company are known to specialize in liquid-propellant motors of the largest sizes, suitable for ballistic-missile propulsion. Rolls-Royce are the managers of the M.o.S. test site at Spadeadam Waste, in the border country in north Cumberland, which is being prepared for the static development of large rocket motors.

Nuclear Power. Administered by the Aero Engine Division is the nuclear research laboratory at Derby Old Hall. The company have been working in this field for three years, and are developing lightweight reactors suitable for a variety of propulsive applications. The Admiralty recently named Rolls-Royce as the contractor for the powerplant of the first British nuclear submarine. Rolls-Royce are also partners with Vickers-Armstrongs and Foster Wheeler in Vickers Nuclear Engineering, formed in 1956.

ROVER. *Rover Gas Turbines, Ltd., Meteor Works, Solihull, Warwickshire.* For several years this off-shoot of the famous car company have been developing a single-shaft gas turbine rated at 60 h.p. This engine is now known as the 1S/60, and is a well-developed, rugged and reliable unit which has found applications in many fields, including aviation.

It is already known that it is the source of power for A.A.P.P. units, one of which—built by Rover themselves, using a Rotax alternator—received limited flight-approval on January 15, 1957, and has since actually flown. This is now being developed to cover main engine starting, in addition to emergency electricity supply for a well-known aircraft: production is expected to start in September.

It is also understood that Rover are "not averse to devoting a portion of their resources to aircraft propulsion," and it is expected that a free-power-turbine unit of over 100 h.p. will be announced at a future date.

SARO. *Saunders-Roe, Ltd., Osborne, East Cowes, Isle of Wight.* Since 1952 this company have been engaged in the development of small flap-valve pulsejets for helicopter tip-drive. All work has been under contract to the Ministry of Supply. The company are also interested in certain aspects of rocket propulsion.

SUGG-SOLAR. *Sugg-Solar, Ltd., 67-73 Regency Street, London, S.W.1.* Since 1956 Sugg-Solar have been licensed to manufacture and market Solar gas-turbine powerplants (*q.v.*).

AUSTRALIA

C.A.C. *Commonwealth Aircraft Corporation, Lorimer St., Melbourne.* This company was established in 1936 for the manufacture of military aircraft and engines. Aircraft production has always been Commonwealth's principal interest but their engines run a close second.

First engine to be built in Melbourne was the Pratt and Whitney Wasp, of which 680 were delivered between 1938 and 1943. In 1940, at the request of the Australian government, the company established a factory at Lidcombe, N.S.W., which produced 870 Twin Wasps before 1945. Later it manufactured 108 Rolls-Royce Merlins and is now chiefly engaged in overhaul work for the Australian Services. The Melbourne factory also made spares for Pratt and Whitney engines and serviced these units throughout the allied forces in the Far East.

In 1947 it was decided to enter the gas-turbine field, and the Rolls-Royce Nene 2-VH was put into production for the Vampire 30 built by D.H. Australia. This engine and the Avon, which is now the company's prime concern, are described below. Total floor space at Melbourne devoted to engine manufacture is 225,000 sq ft, including a 42,000 sq ft light-alloy foundry. Nozzle guide vanes and similar components are produced by the company's own precision-casting unit, and sheet-metal components for powerplants are supplied by the Aircraft Division. Two Detuner-silenced turbojet test houses are in operation and a third cell, capable of handling high-thrust reheat engines, will shortly be in service.

Nene. Described in our April 9, 1954, review, the Nene 2-VH was rated at 5,000 lb at 12,300 r.p.m. and was specially tailored to fit the Vampire 30. The original order for 60 engines was increased to 114, and the last was delivered in 1954. Spares are still being made.

Avon. With the assistance of Rolls-Royce, manufacture of the Avon commenced in the winter of 1953-4. The first type to be built in Melbourne was the Mk 1, a 6,500-lb unit similar to the British Avon 103 and installed in the Australian-built Canberra B.20. Part of the order was later changed to the Mk 109 (British series 109) of RA.7 rating at 7,500 lb-thrust.

At the same time, production started on a fighter Avon of RA.7 rating designated Avon Mk 20 (similar to the British Avon 105). During the past year a later version with improved handling, the Mk 26, has succeeded the Mk 20. These engines are used in the CA-27 Sabre built by the company's Aircraft Division. A total of 180 Avons of the above types is on order, and approximately 140 of these have been delivered.

CANADA

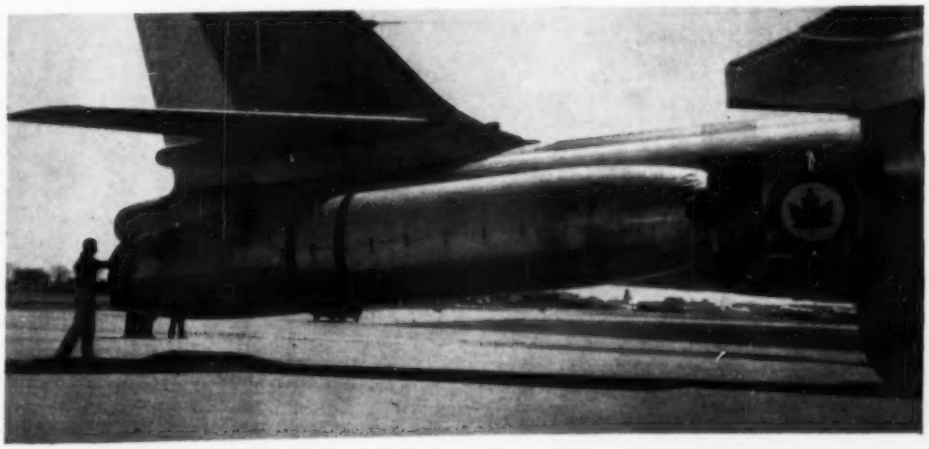
ORENDA. *Orenda Engines, Ltd., Box 4015, Terminal A, Toronto.* During the past year development has gone ahead satisfactorily on the turbojet named Iroquois, one of the largest and most powerful engines being developed anywhere in the world. It is only ten years since Canada began to design and manufacture gas-turbines, yet Orenda Engines remain undaunted by the immense task which lies ahead with this mighty engine.

One of the major firms of the Hawker Siddeley Group, Orenda own a modern and well-equipped 740,000-sq-ft factory at Malton, which was opened on September 29, 1952. From this plant the company have delivered some 4,000 Orenda turbojets to the R.C.A.F. for use in CF-100s and Sabres. Thermodynamic and other types of research are conducted at the government-owned testing station at Nobel, 160 miles north of Malton.

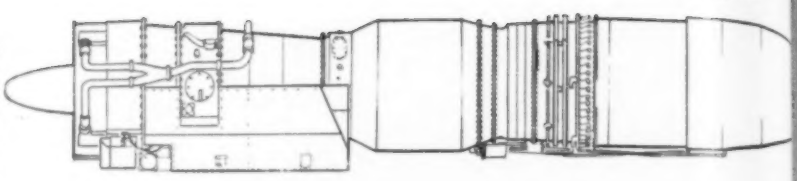
Orenda. Since production began in 1951, the thrust and weight of this single-spool turbojet have respectively been increased and decreased, and the latest production variant is depicted in the drawing overleaf. A similar unit is the Orenda 11 used in the CF-100 all-weather fighter. One of the principal distinguishing features of the CF-100 engines is the provision of a nose-bullet carrying a pair of whirling arms from which alcohol is sprayed to de-ice the intake. The CF-100 Orenda 11 also operates at rather lower j.p.t. than the 14 and gives 7,000 lb thrust. Production is beginning to tail off, and it is unlikely that projected advanced versions of the engine will be built in quantity.

Iroquois. As this engine was originally a private venture, considerable courage was needed by the Hawker Siddeley Group in authorizing its development. It now has full official backing from the Canadian Government and is scheduled to be the powerplant of the CF-105 supersonic intercepter.

The accompanying drawing and data (p. 122) give an idea of the engine's character. As the PS-13, the first prototype was started early in 1955, and numerous examples have now completed a substantial amount of bench running. Orenda's chief engineer, Charles A. Grinyer, last year read a paper on the development of large turbojets in which the advantages gained from substantial use of titanium was stressed; production of these new alloys is a speciality of Canadian Steel Improvement, another Hawker Siddeley company. Marquardt have been named as being



Probably the most powerful engine ever to take the air, Orenda Engines' Iroquois is installed in a nacelle on the starboard side of the rear fuselage of a B-47E. The aircraft was loaned to the R.C.A.F. and converted by Avro Aircraft.



Orenda Engines Iroquois. Two-spool turbojet with short afterburner. Multi-stage low-pressure and high-pressure compressors, annular combustion chamber, independent h-p and l-p. turbines and short afterburner with multiple radial injectors. Approximate diameter, 47in; overall length as shown, about 300in; dry weight, probably about 5,000 lb; mass flow, reported to be about 335 lb/sec; pressure ratio, about 8:1; maximum thrust, about 22,000 lb without reheat. **Note:** This drawing is based on the mock-up.

AERO ENGINES 1957 . . .

engaged in the development of a lightweight afterburner for the Iroquois, and the powerplants for the CF-105 will certainly have such augmentation.

Flight development is taking place with an engine mounted in a nacelle on the starboard side of the rear fuselage of a B-47 which has been loaned to the R.C.A.F. by the U.S.A.F. The airframe was reinforced to take the loads from the big engine, and other alterations include a dorsal spine to house the instrumentation-wiring and removal of the weapons bay and forward auxiliary tanks to make room for a great quantity of test gear. Much of the instrumentation has been developed in Canada and the U.S.A. to Orenda specifications, and it includes numerous multi-channel recorders.

This test-bed has been flying for many months carrying a mock-up engine and is now engaged in actual air-testing programmes. Next year the Avro CF-105 is scheduled to reach an advanced stage of flight-development and, with the possible exception of the first prototype, is scheduled to be powered by a pair of Iroquois. Clearly the engine could form a basis for an even more advanced powerplant running on high-energy fuel.

PRATT AND WHITNEY. *Canadian Pratt and Whitney Aircraft Co., Ltd., 150 Lorne Avenue, Longueil, Quebec.* Production is continuing on the R-1820 nine-cylinder radial engine of Wright design, under a dual licence from the Canadian Government and Wright Aeronautical. Production is reserved entirely for the Canadian-built CS2F-1 Tracker, the prime contractor for which is de Havilland of Canada at Downsview.

R-R. (CANADA). *Rolls-Royce of Canada, Ltd., 6255 Côte de Liesse Road, Dorval, Que.* Since 1951 this company's principal concern has been the Nene 10, some 900 of which were delivered to the Canadian Government for the propulsion of the Canadair T-33AN Silver Star trainer. The majority of these were built in Derby but the Canadian company manufactured 50 and has also served as the source of spare parts. Regular overhaul and repair of the Nene 10 is now supplemented by similar work on the Westinghouse J34 used by the Royal Canadian Navy.

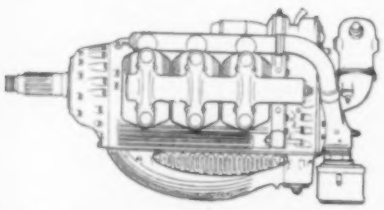
BELGIUM

F.N. *Fabrique National d'Armes de Guerre, Herstal.* When production of the Gloster Meteor was undertaken jointly by Belgium and Holland in 1949 this famous armaments company tooled-up to produce the Derwent turbojet for these aircraft. Before production ceased two years ago deliveries ran to more than 1,000.

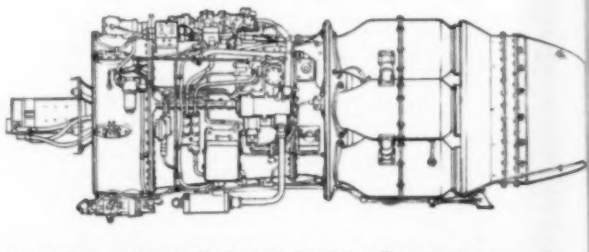
As the Derwent production tapered off F.N. started to manufacture the 100-series Rolls-Royce Avon for the Hawker Hunter (which succeeded the Meteor in the Dutch and Belgian industries). For a considerable time F.N. have now been making the more advanced 200-series Avon, since the Hunters at present being built correspond to the British Mk 6.

CZECHOSLOVAKIA

OMNIPOL. *Omnipol, Prague 3, Washingtonova 11* (National agency for aero engines). One of the most highly developed series of engines in Czechoslovakia is that evolved by the former Walter company. The Walter Minor 4-III was described and illustrated in our review of April 9, 1954. Similar in configuration to our own Gipsy Major, it is now an attractive and reliable design fitted with a Walter carburettor, two Scintilla magnetos and full accessories. Total capacity is 242.87 cu in and the maximum rating 105 b.h.p. at 2,500 r.p.m. with s.f.c. of 0.54.



Praga Doris B. Piston engine. Air-cooled flat-six with geared drive. Width, 37.6in; height, 24in; length, 48.4in; bore and stroke, both 4.528in; swept volume, 437.33 cu in; dry weight, 435.6 lb; maximum rating, 220 h.p. at 3,000 r.p.m. with propeller speed of 1,655 r.p.m. The wavy line on the crankcase is the oil-cooler.



Orenda Engines Orenda 14. Single-shaft turbojet. Ten-stage compressor, six combustion chambers and two-stage turbine. Overall diameter, 43in; length, 123in; dry weight, about 2,470 lb; mass flow, about 130 lb/sec; pressure ratio about 6:1; maximum thrust, 7,200-7,500 lb at 7,800 r.p.m. with s.f.c. of 0.9.

The engine is in production as the standard powerplant of the Super Aero and Metasokol.

The larger Walter Minor 6-III was developed just after World War 2 and put back into production in 1956 for the Trener Z.226 and Akrobats. It uses the same cylinder as the four-cylinder engine and has a maximum rating of 160 h.p. at 2,500 r.p.m.

An entirely new engine is the M 332. An inverted four-in-line, it uses cylinders of similar capacity to those of the earlier Walter engines but runs at 2,700 r.p.m. to give a maximum rating of no less than 140 h.p. It differs from the earlier units in having a mechanically driven supercharger and direct injection; except for the employment of Scintilla (Swiss) magnetos, every part of the engine is of Czech design and manufacture. The M 332 first ran at the end of last year and will be available for installation in the Sokol in about twelve months' time.

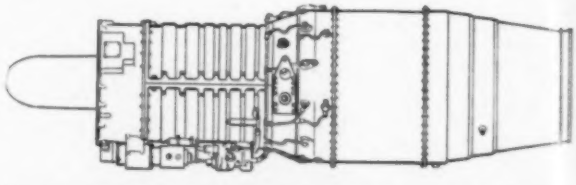
Illustrated in an accompanying diagram is the Praga Doris B, which was first revealed at the Paris Salon in 1955. An exceedingly attractive unit, it has met all I.C.A.O. requirements during a 300-hr type-test, and is now in production for the Agricolta/Brigadyr.

Several types of engine of Soviet origin are also in production at the nationalized Czech factories. For the Avia 14 (Il-14) the M 82 T 14-cylinder two-row radial is now being built. These engines have direct-injection, electric inertia starters and a wide range of accessories, together with an oil-dilution system for use in cold weather. The take-off rating is 1,900 h.p. at 2,600 r.p.m.

FRANCE

DASSAULT. *Avions Marcel Dassault, 78 Quai Carnot, Saint-Cloud.* One of the most successful of French airframe companies, Dassault became interested in aircraft propulsion following the acquisition in 1953 of a licence to develop and manufacture the Armstrong Siddeley Viper. Initially a number of ASV.3 and ASV.5 Vipers were supplied from Coventry, and the latter engine went into limited production at St. Cloud as the M.D.30.

Flight trials of the M.D.30 began early in 1955 with an engine mounted on a pylon above a Languedoc test-bed. Shortly thereafter two M.D.30s were flown up to supersonic speeds at high altitude on the S.O.9050 Trident II, and the engine was then used as the sole powerplant of the twin-engined Mirage I, the engines in the latter installation being handed left and right. Maximum flight Mach-number so far reached is 2. In January 1956 bench-tests began on the M.D.30R reheat Viper embodying an afterburner of Dassault design. Flight trials were again conducted with the Languedoc, and for more than a year intensive flight development has been proceeding with two M.D.30Rs mounted in the Mirage I.



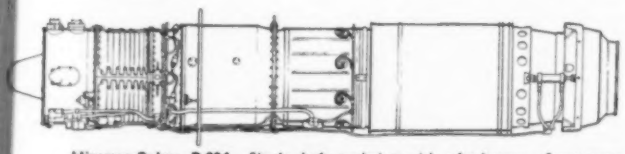
Marcel Dassault R-7. Single-shaft turbojet. Seven-stage compressor, annular combustion chamber with 12 vaporizing burners and single-stage turbine. Overall diameter, 27·25in; overall length as shown, 78.3in; dry weight, 750 lb; mass flow, 55 lb/sec; pressure ratio, 3.8:1; maximum thrust, 3,000 lb at 11,800 r.p.m. with s.f.c. of 1.09. With an afterburner this engine has a thrust of 4,000/4,200 lb.

R.7. The first engine of Dassault design, the R.7 turbojet is virtually a Viper ASV.10 scaled-up to a linear ratio of 1.3. The first of several prototypes began bench trials in December last year, and development is at present very satisfactory. Like the British ASV.10, the R.7 is a very cool-running engine and obviously has great growth-potential. The basic engine is expected to be type-tested in September, and an afterburner giving 32 per cent augmentation (i.e., to a maximum reheat thrust of about 4,200 lb) is at present being developed.

HISPANO-SUIZA. *Société d'Exploitation des Matériels Hispano-Suiza, Rue du Capitaine Guynemer, Bois-Colombes, Seine.* To a certain extent this renowned company could feel that they have had a raw deal from the French government. In the development and mass-production of centrifugal turbojets to basic Rolls-Royce design they have done a superb job, and—the company claim—in 1955 had delivered every turbojet then in service with the French Air Force. They have, however, received no contract for their own axial engine, the R 800 series, neither have they been able to go ahead with plans to manufacture advanced versions of the Avon for the Super Mystère and Caravelle.

Centrifugal engines. Since 1948 total production of the Nene and derived units has exceeded 1,300 engines, and these are still in service with S.E. Mistral and Dassault Ouragan fighters. In 1951 Hispano-Suiza started to produce more powerful engines based on the Rolls-Royce Tay. The ultimate engine, named Verdon, is the standard powerplant of the Mystère IV, and over 550 have already been delivered. Without reheat the Verdon 350 has a dry rating of 7,710 lb and is a useful, cheap and reliable engine. Production of the centrifugal turbojets averaged about 25 per month, and these engines have now flown more than 330,000 hr, with an overhaul life up to 600 hr.

R.804. Depicted in an adjacent diagram, this trim axial has passed all its tests, including a 150-hr type test, but its development has been curtailed by cessation of official support. The company are proceeding with its development on a limited basis, and it may yet be installed in an airframe.



Hispano-Suiza R.804. Single-shaft turbojet with afterburner. Seven-stage compressor, annular combustion chamber with ten burners, single-stage turbine, and afterburner with clamshell nozzle. Basic diameter, 27.2in; length as shown, 146in; dry weight, 833 lb (672 lb without afterburner); mass flow, 57.3 lb/sec; pressure ratio, 4.8:1; maximum thrust, 4,460 lb (without reheat, 3,306 lb at 12,000 r.p.m. with s.f.c. of 1.068).

LEDUC. *René Leduc et Fils, 158 Quai de Bezons, Argenteuil (S. et O.).* For many years René Leduc has been assiduously developing aircraft in which the entire body forms an integral ramjet. Originally almost a lone pioneer, he has now become the head of a considerable company with important government contracts and the prospect of achieving eventual production.

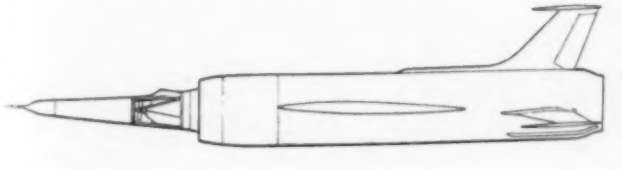
His first integral-ramjet project was conceived in 1933 and a model of it was shown at the 1938 Paris Salon. Developed into the Leduc 010, a contract for a research prototype was placed by the French Air Ministry in 1937. After inevitable interruption during the German occupation M. Leduc finally got the 010 into the air from the back of a Languedoc mother aircraft in April 1949. Three 010s were built, the third having Turboméca Marboré turbojets on the wing-tips. Speeds over 500 m.p.h. were reached, and the rate of climb exceeded 8,000ft/min at 36,000ft.

The Leduc 021 was a larger and faster development, which first flew in May 1953, again launched from the Languedoc. It recorded a level speed of Mach 0.9 and a calculated sea-level rate of climb of 40,000ft/min.

Finally, flight trials are now well advanced on the awesomely impressive Leduc 022, the first supersonic machine in the series and probably the fastest piloted aeroplane in the world. With characteristics indicated by the drawing and data, the 022 is powered by an integral ramjet some 75in diameter and roughly 40ft long, with fuel injected from multiple rings and stabilized by a combination of mechanical and aerodynamic means. For use at take-off, to accelerate the aircraft up to the ramjet light-up and sustaining speed and for use in circuit flying, landing and ground manœuvring, a S.N.E.C.M.A. Atar turbojet is mounted centrally within the duct.

The first 022 was completed in June 1956. It started flying in December and gradually worked up to the start of full-ramjet trials last month. It is currently based at Istres, engaged in flights at increasing speed up to 4,000km/hr (2,485 m.p.h.). The second machine is now also about to fly.

Leduc 022. Supersonic research aircraft with integral ramjet propulsion, supplemented by an Atar turbojet mounted within the duct. Overall length, about 56ft; ramjet diameter, about 75in; ramjet length, about 40ft; gross aircraft weight, 13,200 lb; theoretical sea-level thrust, 132,000 lb; minimum ramjet speed, about Mach 0.4; maximum speed, about Mach 3.5.



Nord ST 450. Supersonic ramjet. Circular-section ramjet with concentric centre-body housing fuel tank (with internal air bottle), control and test gear and recovery parachute system; fore-planes behind intake, and wing cruciform on detachable rear body forming integral combustion chamber. Diameter, 17.72in; length, 185in; launching weight (excluding boost chariot), 385 to 496 lb, according to variations in design or equipment; maximum flight-performance, more than 2,100 m.p.h. at over 75,500ft. This ramjet is being developed for missile propulsion.

NORD. *S.N.C.A. du Nord, 2/18 Rue Beranger, Chatillon-sous-Bagneux (Seine).* For six years the former S.F.E.C.M.A.S. group, who became part of Nord late in 1954, have been developing ramjets for drones, missiles and aircraft. Subsonic ramjets have been described and illustrated in previous engine-reviews (page 581 of our 1956 review, for example).

A supersonic ramjet now undergoing intensive development is depicted in a drawing. It is being test-fired as an integrally powered canard test vehicle, launched at from 60 to 80 deg by a chariot equipped with twin solid-propellant rocket motors. When the tanks run dry the nose section is separated by explosive bolts and is recovered by parachute.

Nord have also undertaken the design and development of an afterburner for the Turboméca Gabizo turbojet (*q.v.*).

POTEZ. *Société des Avions et Moteurs Henry Potez, 46 Avenue Kléber, Paris 16e.* Development and limited production continues upon the integrated range of air-cooled piston engines with four, six and eight cylinders. Typical applications include the Nord 3200 (Potez 4D), Potez 75 and Agusta AZ-8 (Potez 8D). The inverted 8D was described in our 1956 engine review. A recent development is a 1,500/2,200-watt motor/generator set.

SALMSON. *Société des Moteurs Salmson, 102bis Rue du Point du Jour, Billancourt (Seine).* Development, manufacture and spares-production is proceeding upon four basic engines: the 8 AS04 A, an inverted vee-8 of 260 h.p.; the 9 NH02, a nine-cylinder radial of 220 h.p. used in helicopters; and the flat-four 4 AH and flat-six 6 AH, respectively of 100 and 145 h.p. Salmson also repair Lycoming VO-435s of the French Air Force.

S.E.P.R. *Société d'Etude de la Propulsion par Réaction, 37 Rue des Acacias, Paris.* Since World War 2 this company has been the premier rocket organization on the Continent of Europe. Most of their earliest work, dating from 1947, was based directly on pioneer German developments, and attempts were even made to continue some specific German programmes. Soon, however, the company were sufficiently well versed in the art to undertake major design and development tasks completely unaided.

One of their first major assignments was to study and evaluate the whole range of suitable propellant combinations for aircraft and missile motors: the French Air Ministry and S.E.P.R. finally chose a mixture of 98.5-per-cent nitric acid and furaline (furfuryl alcohol) in the ratio 2.4:1 by weight. Conflicting international interests are now leading to an unfortunate amount of lobbying in an endeavour to promote one country's choice of propellants and denegrate all alternatives. S.E.P.R. are committed to the above choice and are striving assiduously to show that it is a correct one. In this connection it is of interest to note that for some years the company have been developing a liquid inhibiting additive for the acid—a complex of phosphates—marketed under the name Omnifos; components such as Argonarc-welded pump rotors have lost no weight after one month in the inhibited acid, even though the parts themselves have no surface protection.

Like its British counterpart the Armstrong Siddeley Screamer, the first S.E.P.R. aircraft motor was intended for installations in which a source of shaft-power to drive the pumps was already available. Designated S.E.P.R.25, this experimental and development motor employed a single chamber, which, like those of all succeeding S.E.P.R. liquid-propellant motors, was made of light alloy and regeneratively cooled by the acid. Rated at 3,300 lb at sea level and 3,660 lb at 49,200ft (no thrust-variation was possible), the 25 and 251 motors were extensively flown between 1952 and 1954 in the S.O.6025 and 6026 Espadons.

From this unit have been developed the more recent powerplants described below. S.E.P.R. are also major producers of solid-propellant motors for aircraft a.t.o., missile and test-vehicle applications.

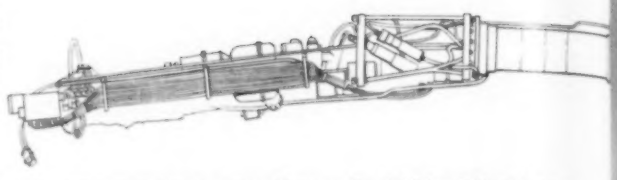
Head office of the company is at the address quoted above. The main production factory is at Argenteuil, near Paris, and test establishments are maintained at Villejuif (Seine), Melun-Villaroche (Seine et Marne) and at Istres (Bouches du Rhône).

481. This unit was S.E.P.R.'s first self-contained aircraft powerplant, comprising a turbopump feeding three barrels each similar to that of the 25-series motor, together with a complete control system. The powerplant was designed for Ouest Aviation (then Sud-Ouest) for the S.O.9000 Trident I. The airframe company specified turbopump location near the trailing edge of the wing and the combustion-chamber group at the extreme tail.

Starting is effected by an electric motor which turns three micro-pumps feeding nitric acid, furaline and water/methanol to a gas generator. After 0.55 sec the generator valve opens and the resulting combustion provides a working fluid for the main turbine, which is a single-stage Laval impulse wheel with six injectors. When turbine r.p.m. reaches that of the micro-pumps the drive is transferred from the electric starter which is taken out of circuit. When the pressure has built up sufficiently the propellants are automatically admitted to No. 1 chamber, and full thrust in this chamber can be obtained about three seconds after pressing the starter button. Chambers 2 and 3 can then be fired as desired. The turbopump operates at constant r.p.m. and excess propellants are recirculated.

During its 2½ years' development the 481 motor completed 1,100 test-stand runs and 120 flights in the Trident; the chambers were fired some 2,700 times and there was "no serious failure." Flying of the

S.E.P.R.66 (shown with twin 3,300-lb chambers). Aircraft rocket motor. Single- or twin-chamber pump-fed rocket motor for piloted aircraft, with regeneratively cooled, constant-thrust chambers operating on nitric acid and furaline. Overall width, 23.6in; height, 11.8in (from top to bottom at any given location); length, 110.2in; dry weight (two 3,300-lb chambers), 352 lb; maximum thrust, 6,600 lb at sea level, or about 7,260 lb at 40,000ft; specific propellant consumption (including turbo-pump), 0.0052-0.0054 lb sec/lb at s. l., 0.00475-0.0049 lb sec/lb at 40,000ft.



AERO ENGINES 1957 . . .

Trident I ceased early last year, the design figure of Mach 1.6 at 62,000ft having been exceeded.

631. This unit is a straightforward development of the 481. It is essentially an improved and "cleaned-up" unit equipped with two chambers each of the standard 3,300-lb rating. It was developed for the S.O.9050 Trident II and flew in that aircraft for some 15 months before the machine was destroyed—through no fault of the power-plant—late in May of this year.

65. Unlike the main S.E.P.R. family of liquid-propellant motors, this unit has a single small chamber rated at only 1,819 lb-thrust. The chamber has a greater characteristic length than the standard design, and the unit is made up into a self-contained pack which is fitted beneath the Atar turbojet in the S.E.212 Durandal.

66. By successive refinements the 66-series has been evolved from the 25/481 as a self-contained powerplant for operational employment in intercepters. The propellants, feed, starting and control system are all similar to those of the 481, but all units are mounted axially along a light-alloy truss frame which can be installed and removed as a unit. Compared with the 481 the thrust/weight ratio is much improved, the dimensional envelope is reduced and installation is easier. On to the basic S.E.P.R.66 assembly can be fitted either one or two combustion chambers each rated at either 1,650 or 3,300 lb at sea level. The prototype S.E.P.R.66 has been flying in the Super Mystère IV B-1 with a single 3,300-lb chamber, and a modified unit is also flying in the M.D.550 Mirage I. Later developments are to be fitted to several advanced French intercepters.

Solid motors. Mass-production of solid-propellant boost motors for guided weapons and test vehicles and for various a.t.o. applications is a major occupation of the company's production plant. Typical units are the series-78 a.t.o. motor giving 2,540 lb-thrust for two seconds, the 685 wrap-round surface-to-air missile boost motor giving 9,500 lb for 3.75 sec, the 5054 tandem booster for test vehicles or missiles giving 34,800 lb for 3.5 sec and the 732 tandem motor for large missiles rated at 44,500 lb for 4.45 sec. Manufactured in particularly large numbers are relatively small—and often smokeless—motors for air-to-air weapons, such as those by the Matra Company.

S.N.E.C.M.A. *Société Nationale d'Etude et de Construction de Moteurs d'Aviation, 150 Boulevard Haussmann, Paris 8e.* This organization was formed in 1945 by the amalgamation of the aircraft-engine activities of former private companies such as the Société Gnôme et Rhône and the Société des Moteurs Renault de l'Aviation. The company is easily the largest aero-engine firm on the Continent of Europe; total payroll exceeds 10,000 and the turnover in 1956 was 29.8 milliards (£30.4m).

The address above is that of the head office in the centre of Paris. Virtually all S.N.E.C.M.A.'s operations are conducted at various establishments on the outskirts of Paris. At Gennevilliers is a large forging and smelting plant, Billancourt is the centre of operations on piston engines and the Kellermann works undertakes the manufacture and repair of turbojets; general research (including work on atomic propulsion) and the manufacture of prototypes is the responsibility of the facility at Suresnes, and at Villaroche is a large and well-equipped ground and flight test establishment.

By far the major production task concerns the Atar turbojet; the development of the Vulcain and Vesta is not being proceeded with. A licence to manufacture the Orpheus turbojet was recently obtained from Bristol. In addition to the development of the units described under separate headings, ramjets form a major part of the company's activities.

During the past four years S.N.E.C.M.A. have undertaken increasingly intensive research into V.T.O.L. problems using jet-propulsion engines mounted vertically. The earliest work was conducted with rigs comprising resonant-duct pulsejets fed with fuel through a hose to the ground. Trials then investigated the problems associated with running a vertical Atar, and these culminated in the successful tethered and free flights of the *Atar Volant*. The first of these vehicles was remotely controlled from a ground station, and the second is flown by a pilot in an ejection seat above the air intake. Control is effected by deflecting the main efflux by means of compressor-bleed jets issuing from slits around the Atar propelling nozzle. Additional bleed jets are mounted on radial arms to provide control in yaw. Later, an annular wing will be fitted to an *Atar Volant* to form a coleopter, a field in which S.N.E.C.M.A. have long been interested and for which they hold certain European rights. Coleopter airframes will be manufactured by the S.N.C.A. du Nord.

Another development concerns the use of air jets to stabilize afterburner flames and also to vary propelling-nozzle area in supersonic powerplants. In addition S.N.E.C.M.A. were one of the first to produce a successful turbojet thrust-reverse mechanism, employing concentric cascades into which a proportion of the jet is deflected by means of retracting baffles. Licences in respect of this equipment have been granted to Bristol and Aerojet-General.

Atar. As in previous years, this engine remains the most important manufactured in any Continental country. Simple and reliable, it has proved a basis for long and successful development and the later versions are fully competitive with units produced in other countries.

Its genesis lay in B.M.W. work during World War 2, and the German company's chief designer, Dr. Oestrich, has been in charge of Atar development. The first prototypes were completed in 1948 and were rated at 3,740 lb. Early production engines were fitted with a sliding bullet in the tailpipe to control the area of the propelling nozzle, and variable nozzles have since been employed on all Atars—whether equipped with an afterburner or not—to meet a French Air Ministry requirement for the matching of jet-pipe temperature and r.p.m. under all conditions.

First of the Atar family to go into production was the 101 D-1 for the Mystère II. Compared with preceding Atars the D-series have 20 per cent better pressure ratio and 16 per cent greater airflow, and they are still in service with Mystère squadrons at an overhaul life of 300 hr. Afterburning versions of the D are designated 101 F; these units, rated at 8,370 lb reheat-thrust, were first tested in the winter of 1952/53. Fuel is injected from radial pipes and the flame stabilized by a pair of circular gutters; the clam-shell nozzle comprises upper and lower segments actuated hydraulically.

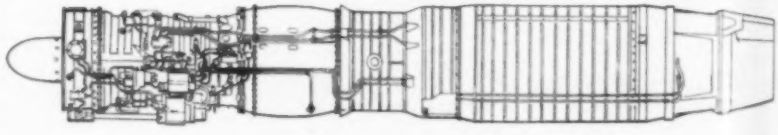
The current versions of the Atar at present in production are the 101 E and its afterburning version the 101 G. In the E-series an extra stage is added to the compressor (previous engines having but seven stages), the first-stage blades being of steel. In addition, the governed speed has been raised to 8,400 r.p.m. Several hundred 101 E-3s are being built for the Vautour at a rating of 7,702 lb dry. Already these engines have qualified for an overhaul life of 500 hr, and E-3s have run continuously for over 1,000 hr on the bench.

In addition, many 101 G-2 afterburner engines, rated at 9,700 lb reheat-thrust (7,650 lb dry), are being delivered for Super Mystères and other high-speed aircraft. All aspects of the operation of the Atar up to the G-series have been thoroughly explored. Handling is good under all conditions, and life and reliability are very satisfactory owing to the inherent ruggedness of the design. The latest variants of this generation of the Atar are the E-5 rated at 8,150 lb-thrust and the G-2A rated at 10,400 lb-thrust.

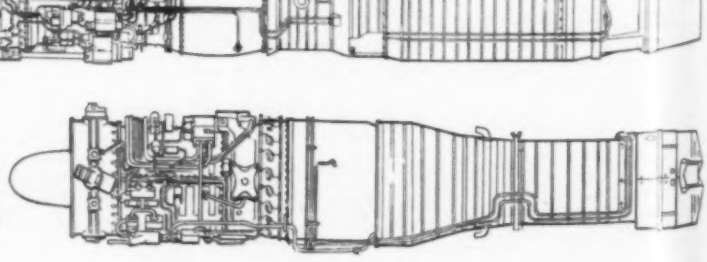
Later models of the Atar are designated by a number instead of a letter, and the first of the new generation is the Atar 8. This engine introduces a new compressor with nine stages of blades (1,335 blades are fitted to the compressor and turbine combined) which results in a substantially increased pressure ratio and mass flow. The installational diameter of the engine is actually somewhat less than that of the Atar E, and the accessories have been regrouped. Atar 8s are at present in limited production at a rating of 9,700 lb dry, and the engine is flying in the Etendard IV.

Already coming into production is the Atar 9, the reheat version of the Atar 8 and the most powerful Atar yet developed. In September the Atar 9 should fly in a Super Mystère and it has been chosen to power the Mirage IIIA, the Griffon and other aircraft.

In order to increase output still further, advanced versions of the Atar 8 and 9 are to be fitted with a transonic all-steel compressor for operation at flight Mach numbers ranging from 2.5 to 3. Moreover, one or more rows of variable stators are to be incorporated.



S.N.E.C.M.A. Atar 9. Single-shaft turbojet with afterburner. Nine-stage compressor, annular combustion chamber with 20 burners, two-stage turbine, afterburner with aerodynamic flame-holding and multi-position nozzle. Diameter over turbine casing, 33.86in; overall length as depicted, 263.8in; dry weight, 2,755 lb; mass flow, 149.9 lb/sec; pressure ratio, 6.9:1; maximum thrust, 13,228 lb at 8,400 r.p.m. with s.f.c. of 2.075 at full reheat, or 11,905 lb with s.f.c. of 1.7 at partial reheat, or 9,370 lb with s.f.c. of 1.1 dry. The non-afterburning Atar 8 weighs 2,028 lb and has a dry rating of 9,700 lb with s.f.c. of 0.98.

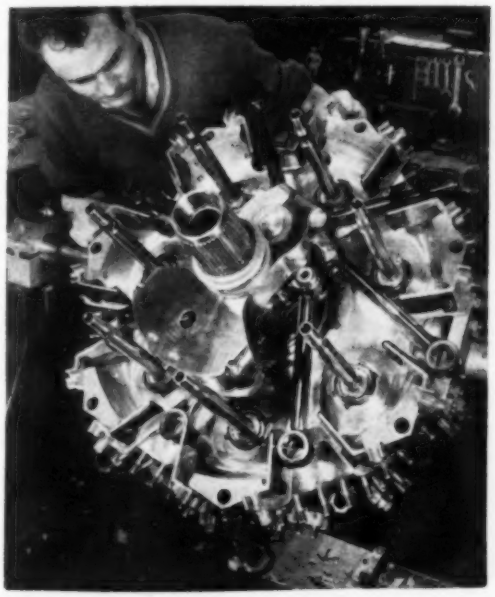


S.N.E.C.M.A. Atar 101 E-5. Single-shaft turbojet. Eight-stage compressor, annular combustion chamber with 20 burners, single-stage turbine and variable-area propelling nozzle. Maximum height, 39.1in; maximum width, about 36in; length as shown, 177in; dry weight, 1,829 lb, or 2,050 lb as complete engine-change unit; mass flow, 130 lb/sec; pressure ratio, 5.5:1; maximum thrust, 7,716 lb at [illegible] r.p.m. with s.f.c. of 1.05.

Pulsejets. Development is continuing upon valveless resonant-duct engines. After concentrating upon units which are, figuratively speaking, bent back upon themselves (one of this family was described and illustrated in our 1956 engine review) development is proceeding upon various forms and sizes of engines operating on a range of fuels. Much of the development is at present aimed at helicopter and transonic missile and drone applications. In addition, Hiller Helicopters (*q.v.*) expect to licence-build S.N.E.C.M.A. pulsejets for an unusual application.

Piston engines. As described in the 1956 review, S.N.E.C.M.A. are licence-producing the Bristol Hercules 758 sleeve-valve radial engine rated at 2,000 h.p. The expanded programme for the Noratlas transport has caused orders to be stepped up to a total of about 1,000 engines, and over 500 have already been delivered from the former Renault works at Billancourt.

Production is also being maintained on the 12S inverted vee-12 air-cooled piston engine of 600 h.p. An improved version of this engine, designated S.N.E.C.M.A. 12T, was recently certificated. An effective increase of 30 h.p. is obtained by utilizing exhaust thrust; improvements have been made to the throttle control and handling and the scheduled overhaul time is 1,000 hr.



S.N.E.C.M.A. have already delivered 500 Bristol Hercules.

TURBOMECA. *Société Anonyme Turboméca, Bordes (Basses-Pyrénées).* Before 1939 this company specialized in high-efficiency centrifugal blowers, but the director-general, M. Szydlowski, studied the problems of small gas-turbines during the German occupation of France. An entry to the new field was provided by a Ministry of Air development contract for a gas-turbine alternator set rated at 100 kW at 19,200ft altitude. This was developed into the Oredon turboshaft engine of up to 180 h.p. By removing the shaft-drive and one of the two turbine stages the engine was converted to the Piméné turbojet, which flew as the powerplant of the Sylphe aircraft at a rating which eventually reached 243 lb.

By 1950 the Piméné had been scaled-up to form the Palas, rated at 353 lb-thrust, and the Oredon had been similarly scaled to produce the 280-s.h.p. Artouste I, formed from the abandoned Arrius shaft-turbine and the Palouste (below). At the same time the Ministry of Air requested development of a turbojet of 705 lb-thrust and design began on the Marboré I. The latter was never produced, being superseded by the 882 lb-thrust Marboré II. Also in the 1950 era, the Piméné compressor was linked with the Oredon turbine to give the Pimédon air compressor. Used as a volumetric displacement pump the Pimédon gave a startling demonstration by emptying a dock at Toulon, and the publicity added new impetus to the company's operations.

From the Palas compressor and Artouste I turbine a large air producer named Palouste was evolved. Another aircraft powerplant was the Turmo, which started life as a weighty unit for armoured fighting vehicles; it was the first small free-turbine engine in the world. Another "first" was the Aspin by-pass engine, which was flown in the Gemaux and achieved the remarkable specific consumption of 0.53.

Current Turboméca engines are described below. Total employment in the company is approximately 1,500. The main plant at Bordes is in the foot-hills of the Pyrenees, the company having moved there in 1940 to escape occupation. Turboméca do not have their own foundry but they conduct a great deal of research into accessories and manufacture their own fuel systems. Complete gearboxes are made at the company's other factory, employing about 100, at Epone, Mezières (Seine-et-Oise).

Marboré. Since 1953 this engine has been the company's main production item and over 1,000 are being manufactured for the Magister trainer. A typical example is illustrated in the section dealing with Continental (U.S.A.).

Production has centred upon the Marboré II, and these are usually delivered as complete powerplants with equipment suited to the Magister, Paris or other applications. The most recent engines have a scaled Gabizo (below) combustion chamber with which increased overhaul times are possible; 300 hr has been fixed as the initial life of the new chamber. Another design-change results in an increased mass-flow. A special low-cost variant is used as the powerplant of the Nord CT-20 target. Production licences are held by Continental (U.S.), Spain and Yugoslavia, and discussions are being held with Western Germany.

Palas. One of the earliest Turboméca engines, the Palas is fitted to the Midjet and Minijet, and British-built versions (see Blackburn) are used in the SK-1, Sparrowjet and, optionally, the Student. A licence-to-build is held by Yugoslavia, who have fitted French-built engines to several aircraft of their own design. The Palas is also employed in a.t.o. booster nacelles fitted to Varig DC-3s, various C-46s and the Noratlas and S.O.30P. For the a.t.o. applications Turboméca supply bare engines to Ouest Aviation and Sferma, who co-operate to deliver complete equipped nacelles.

Arbizon. Steady research led in 1955 to a range of more-efficient engines, in which the specific design-point was improved by the addition of an axial compressor stage to supercharge the centrifugal impeller. The revised range of engines are more efficient and have greater mass-flow and better specific consumption, and appreciably greater output than earlier units of comparable size and weight. The Arbizon can be regarded as a "supercharged Palas." It has no flying application at present.

Gourdon. The Gourdon was first revealed at the 1955 Paris Salon. It is in effect a supercharged Marboré IV, the latter being for American requirements. The Gourdon is 22.3in in diameter, weighs 375 lb and has a take-off thrust of 1,410 lb with a specific of 0.99.

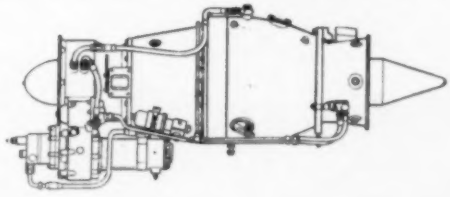
Gabizo. Present indications are that this will be the most important of the company's current engine programmes. An entirely new design, it is the largest engine yet made by the company and represents the next stage in development beyond the Gourdon. It was planned to meet the requirements of the French Ministry of Air specification for light twin-engined fighter and attack machines for NATO, and it won in competition with Hispano-Suiza and S.N.E.C.M.A.

General design is shown by the drawing, and the engine is being developed in company with an afterburner which increases thrust by 40 per cent. Afterburner development has been assigned to the S.N.C.A. du Nord (the propulsion section, formerly SFECMAS) who have had much experience with ramjet development. The two-position nozzle has twelve shutters which are moved by four interlinked electric actuators; reheat-ignition is by a system of the hot-streak type. Extensive development is now completed, and air trials began last year with a reheat Gabizo slung beneath a test-bed Canberra.

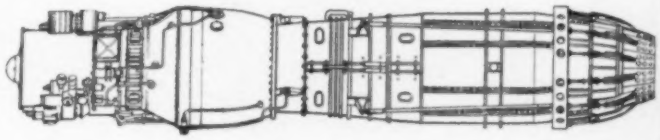
The basic Gabizo passed its 20-hr qualification test in May 1955 and the full 150-hr type-test in December of the same year. A 2.5 kW starter/generator is fitted and ignition is by a pair of high-energy plugs. Two mechanical drives, of 15 and 25 h.p., are available and air can be bled from two pads on the main housing. The engine is flying in the Bréguet 1100, Etendard II, C.M. 171 and 172 Makalu, S.O. 9050 and M.D. 550; a commercial variant has been selected for the M.S. transport project.

Artouste. A single-shaft turbine, the Artouste has been used to drive auxiliary power-packs and for the prime propulsion of aircraft and helicopters. Development has been centred on the Artouste II, which is in full production as the powerplant of the Alouette II helicopter. In this aircraft the engine has a 200-hr overhaul life, and 300-hr is in immediate prospect. Should Republic undertake American licence-production of the Alouette, Turboméca would supply Artouste II engines to Continental (*q.v.*) who would convert the units to American standards, up-rate them to 425 h.p. and ship them to Republic as the Model 220-2. The standard Alouette engine has a take-off rating of 360 h.p. at 5,780 output r.p.m. (33,000 turbine r.p.m.) for consumption of 385 lb/hr. Overload and maximum-continuous ratings are respectively 400 and

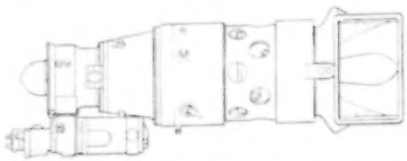
Turboméca Arbizon. Single-shaft turbojet. Single transonic axial compressor stage followed by single centrifugal stage, annular combustion chamber and two-stage turbine. Overall height, 19.9in; overall width, 16.4in; dry weight, 230 lb; maximum thrust, 550 lb at 34,000 r.p.m. with s.f.c. of 0.92 (max. cont., 440 lb).



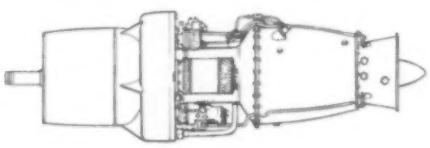
Turboméca Gabizo. Single-shaft turbojet with afterburner. Single transonic axial compressor stage followed by single centrifugal stage, annular combustion chamber, single-stage turbine, and afterburner with two-position nozzle. Overall diameter (on reheat pipe), 26.77in; intake diameter, 17.7in; overall length as shown, 142.2in; dry weight, about 740 lb; mass flow, about 45 lb/sec; pressure ratio, about 5:1; maximum thrust, 3,396 lb at 17,500 r.p.m. with s.f.c. of 2.25. The basic engine weighs 585 lb and has a rating of 2,420 lb with s.f.c. of 1.05.



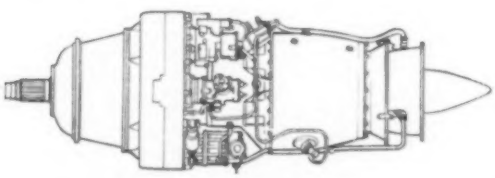
AERO ENGINES 1957 . . .



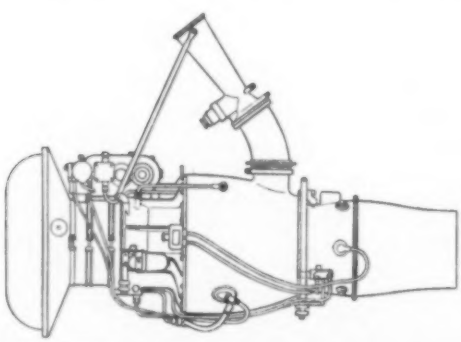
Turboméca Turmo III. Free-turbine engine. Single transonic axial compressor stage followed by single centrifugal stage, annular combustion chamber, two-stage compressor turbine and independent single-stage power turbine. Overall width, 29.4in; overall height, 22.25in; overall length, 65.6in; dry weight, 530 lb; mass flow, about 10.6 lb/sec; pressure ratio, about 5.1:1; maximum rating, 750 h.p. at 34,500 r.p.m. (6,000 output r.p.m.) with s.f.c. of 0.77. A take-off rating of 900 h.p. with a maximum overload of 1,000 h.p., is foreseen for the near future.



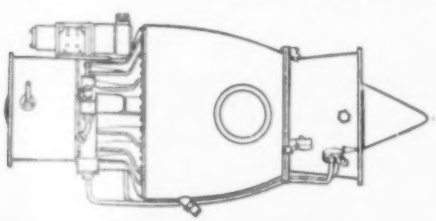
Turboméca Astazou. Single-shaft turboprop. Single transonic axial compressor stage followed by single centrifugal stage, annular combustion chamber and multi-stage turbine. Overall diameter, 18.1in; length as shown, about 69in; dry weight, 245 lb; mass flow and pressure ratio, not available; maximum rating, 320 h.p. at unstated r.p.m. with s.f.c. of 0.72 (this power is limited by reduction-gear capacity and is available up to 92 deg F, or up to a height of 15,000ft at Mach 0.45).



Turboméca Bastan. Single-shaft turboprop. Single transonic axial compressor stage followed by single centrifugal stage, annular combustion chamber and multi-stage turbine. Overall diameter, 21.6in; length as depicted, 60.9in; dry weight, with propeller but without oil-cooler, 585 lb, or 397 lb without propeller; mass flow and pressure ratio, not available; max. rating, 650 s.h.p. at 33,000 r.p.m. (1,790 propeller r.p.m.) with s.f.c. of 0.73, available up to 14,800ft at Mach 0.4.



Turboméca Palouste IV. Air compressor. Single centrifugal compressor, annular combustion chamber and two-stage turbine. Overall height as depicted, about 34in; width, about 21.6in; overall length, 52.3in; dry weight, 198 lb; pressure ratio, 3.7:1; maximum output, 2.51 lb/sec of air at 41.2 lb/sq in gauge at 34,000 r.p.m. with fuel consumption of 265 lb/hr; max. cont., 2.4 lb/sec.



Turboméca Tramontane. Air compressor. Single centrifugal compressor, annular combustion chamber and two-stage turbine. Overall diameter, 22.75in; length, excluding tail-cone, 47.3in; dry weight, 370 lb; mass flow, about 16.7 lb/sec; pressure ratio 5.1:1; maximum output, 5.5 lb/sec of air at about 38 lb/sq in gauge at 22,600 r.p.m. with fuel consumption of 680 lb/hr; max. cont., 5.1 lb/sec.

320 h.p., and the engine weight is 243 lb. Artouste IIs have also flown in the S-59 and XH-13F helicopters in the U.S.A.

An advanced derivative is the Artouste III which is the supercharged derivative of the earlier unit. The new engine has yet to fly, but it has recorded from 600 to 700 b.h.p. on numerous bench trials.

Turmo. The engine illustrated is the latest of the company's free-turbine units and it can be regarded either as a supercharged Turmo II or a free-turbine Arbizon. Applications include new projects by Sud-Aviation and Bréguet.

Marcadau. This name applies to the Artouste II turboshaft engine fitted with a reduction gearbox and equipped as a turboprop. The powerplant weighs 350 lb without cowling or propeller, and is fitted to the Cessna L-19C and the Farfadet convertiplane.

Astazou. About a year ago Turboméca started from scratch on a new series of engines incorporating all the experience gained with earlier units and designed to advanced techniques. These extremely attractive and refined powerplants at present comprise the Astazou and Bastan turboshaft engines, and other engines designed to the new techniques may be expected to appear.

Development of the Astazou has been straightforward and prototypes are about to run on the bench. The basic gas-producer section is extremely minute, being dwarfed by the reduction gear and two-blade Ratier propeller. A row of miniature accessories is carried around the back of the main intake casting.

Bastan. Most powerful of the company's turboshaft engines, the Bastan is the second of the "new generation" of highly efficient small turbines. Bench trials should be well advanced by the end of the year and development is taking place against a prototype contract.

At the front is the two-stage reduction gear, contained within a series of intake castings around the back of which is a peripheral row of gear-trains for driving the accessories. Typical equipment includes a Ratier-Figéac control unit, a Labinal 2.5 kW starter/generator and a three-blade constant-speed hydraulic propeller of 9ft 3in diameter, the pressure oil for which is tapped from the engine system. Compressed air can be tapped from the main casing, and a 15 h.p. mechanical drive is available, turning at up to 6,810 r.p.m. The Bastan has been selected to power the M.S. 1500 Epervier, the S.O. 1100 Fonceur and Super Broussard 02. Future developments are expected to lead to a maximum rating of 750 h.p. with an s.f.c. of 0.77, largely by raising the top temperature.

Soulor. First shown at the 1955 Paris Salon, the Soulor is a ducted-fan engine with a maximum thrust of 705 lb. It was described and illustrated in our 1956 engine review. It is at present being further developed as one of the engines of the new high-efficiency generation.

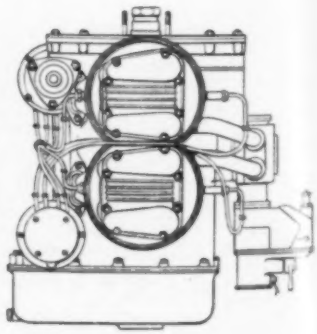
Palouste. The engine illustrated is the latest of a series of turbo-compressor engines which are in production as the powerplant of the S.O. 1221 Djinn helicopter. Compared with its predecessors, the Palouste IV has a redesigned turbine-end giving better operating characteristics. The engines are delivered as complete powerplants which are readily interchangeable in the field. Starting can be effected either by a hand-crank or by an electric motor or a small two-stroke piston engine. A sonic "flow-limiter" controls the output from the single pipe-connection above the main casing.

Autan. Embodying a supercharging axial stage, characteristic of the generation of engines introduced in 1955, the Autan can be regarded as a supercharged Palouste IV with correspondingly greater output and efficiency. In appearance it is much like the Arbizon, and it provides an output of 3 lb of air per second, at a pressure ratio of 5.1 : 1 at 34,500 r.p.m. The overall diameter is 16in and the weight 260 lb. It is worth noting that the Soulor ducted-fan unit is virtually an Autan in which the bleed air, instead of being extracted through a pipe, is expelled as a propulsive jet.

Tramontane. This engine is a natural development, in that it is an air-compressor with a centrifugal impeller of Marboré size. It is in an early stage of development and its existence was only made public two months ago. Unlike the previous compressors, air is supplied from two outlets, one on each side of the main casing.

ITALY

AGUSTA. *Meccanica Verghera Agusta, Gallarate (Prov. Varese).* Long established in the automotive field, Agusta entered aviation as a licence-producer of Bell helicopters, of which more than 250 have been



Agusta G.A.70 V. Piston engine for helicopters. Horizontally opposed four-cylinder engine mounted with crankshaft vertical, with float-chamber carburettor, dual ignition and electric starter; gearbox or fan not shown. Overall width, 28.9in; height as shown, 22.8in; length, front to rear over carburettor, 21.25in; swept volume, 140.4 cu in; dry weight, 147.7 lb; maximum rating, 72 h.p. at 3,100 r.p.m. at engine shaft.

proof against vibration or flexing in high ambient temperatures

There is an increasing need for flexible pipes capable of working in positions where they are subjected to vibration or flexing in high ambient temperatures.

Effective in temperatures minus 55° to 400°C.

Dunlop "Fleximet" pipes are all-metal assemblies developed to work in a temperature range of minus 55° to 400°C in aircraft fuel, oil and oxidant systems.

Designed for high and medium pressure ranges

They are manufactured in two types. The high pressure assemblies are extremely flexible, and are designed to work at pressures up to 6000 p.s.i. with low fluid flow. The medium range working pressures vary according to bore diameter and are capable of handling relatively high fluid flows.

Details on application

These all-metal pipes are a valuable addition to the range of conventional flexible pipes employing rubber hose already available. Further details of "Fleximet" pipes can be obtained from:—

DUNLOP RUBBER CO. LTD., AVIATION DIVISION, ST. GEORGE'S ROAD, COVENTRY

DUNLOP 'FLEXIMET'
ALL-METAL FLEXIBLE PIPES FOR AIRCRAFT SYSTEMS

—another Dunlop service to aviation!

6H/625

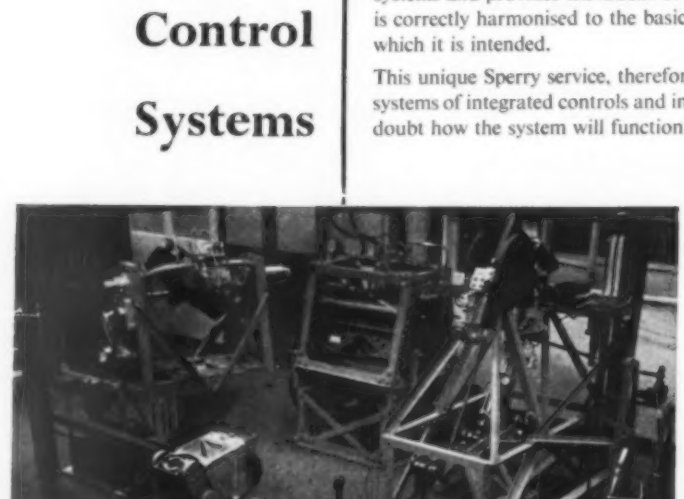
SPERRY

Integrated Control Systems

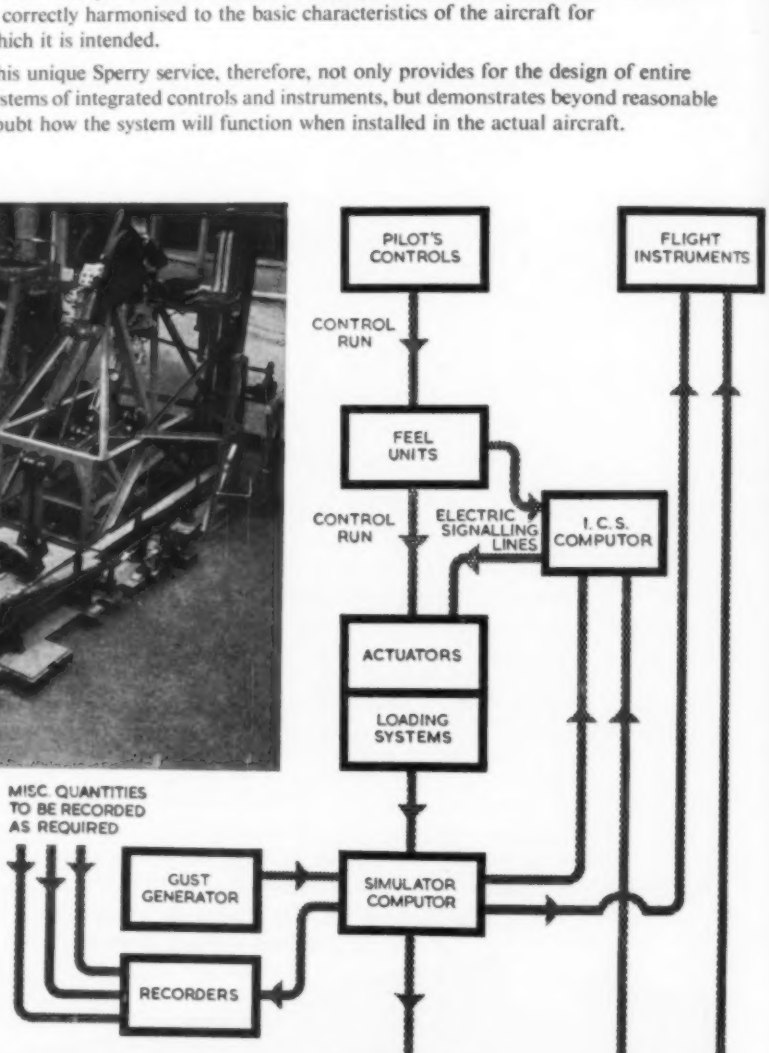
In conjunction with its development of integrated flying control and instrument systems, Sperry has now produced a simulator for testing such systems under fully realistic flight conditions, which ranks amongst the most advanced installations of this type in the industry.

This simulator has been designed to accept a wide range of control and instrument systems and provides the means of ensuring that the particular system installed is correctly harmonised to the basic characteristics of the aircraft for which it is intended.

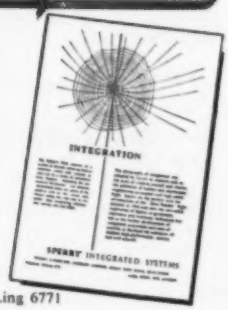
This unique Sperry service, therefore, not only provides for the design of entire systems of integrated controls and instruments, but demonstrates beyond reasonable doubt how the system will function when installed in the actual aircraft.



General view of the Sperry Simulator Laboratory

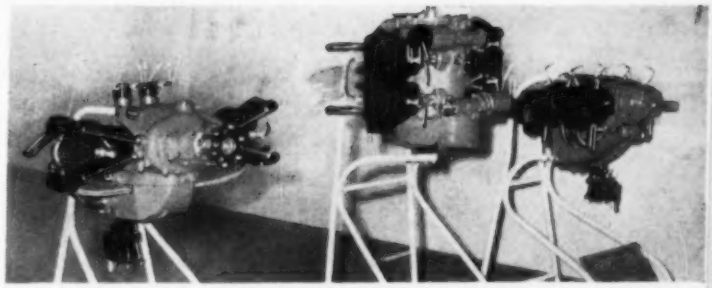


The Sperry Simulator Computor



SPERRY GYROSCOPE COMPANY LIMITED · GREAT WEST ROAD · BRENTFORD · MIDDLESEX · TELEPHONE: EALing 6771

The small piston engines from the Agusta company were revealed at the recent Paris Salon: from the left, G.A.40, G.A.70/V and G.A.70/O.



AERO ENGINES 1957 . . .

delivered. In 1955 M. Ginnini designed an exceptionally attractive range of completely new small piston engines for the propulsion of fixed-wing aircraft and helicopters.

Smallest of the range is the flat-twin G.A.40 with a displacement of 1,486 c.c., a weight of 86 lb and a rating of 42 h.p. at 2,700 r.p.m. Limited production is in hand for the take-off propulsion of a motorized glider for the Italian Air Force.

Using a slightly smaller cylinder-size, an opposed four-cylinder engine designated G.A.70 is now being developed in two forms. That depicted in the diagram is for helicopter propulsion, and has the crankshaft vertical. The fixed-wing G.A.70/O has a similar rating and weighs 150 lb. All these engines are at present undergoing bench-testing, and type-certification should be completed by the end of this year.

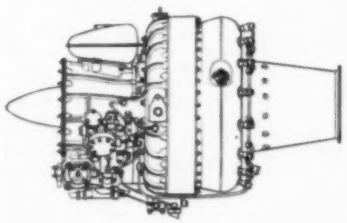
FIAT. *Fiat S.p.A., Divisione Aviazione, Corso G.Agnelli, 200, Turin.* By far the largest firm of its type in Italy, the giant Fiat organization have been making aero engines since 1908. Since World War 2 the company have successfully weathered the period of depression which crippled many Italian firms and have firmly established their position in the gas-turbine field.

During the past decade the bulk of the company's aero-engine work has been centred on the works at Lingotto, built and equipped specifically for competitive operations in both the piston and turbine fields. The manufacture of piston engines ceased shortly after World War 2, but overhaul and spares-production have remained major activities, both for Fiat engines and for such imported units as the Pratt and Whitney range of radials, Wright Turbo-Compound, Rolls-Royce Merlin 500 and Packard Merlin V-1650.

Gas-turbine operations started ten years ago with the manufacture of spares for the D.H. Goblins of Italian Air Force Vampires. Four years later the Lingotto plant tooled-up to build the D.H. Ghost 48 Mk 1 turbojet for delivery to Sud-Aviation at Marignane, where the Aquilon (development of the Sea Venom) was in production. Total deliveries to Sud Aviation were in excess of 110 engines.

In 1953 Fiat were awarded their first American off-shore contracts, the largest being worth some £3m and covering the overhaul and production of spares to support the Allison J35-A-29 turbojet, which was then widely used in NATO as the powerplant of the F-84G. Similar contracts have since been placed for the General Electric J47—for which engine Fiat is the European overhaul centre—and Curtiss-Wright J65 Sapphire for U.S.A.F.E.

The company decided to try their skill at the design of their own gas turbine in 1953. Having designated the Goblin the Fiat Model 4000, and the Ghost the Fiat 4001, the company-designed engine became the Model 4002 (axial units have a different system of nomenclature). The 4002, which has yet to fly, is described below. It is being followed by two more Fiat-designed units about which no details may yet be published: the Model 4033 (*sic*) turbojet of greater output than the 4002, and the Model 4700 compressed-air generator.



Fiat 4002.001. Single-shaft turbojet. Single centrifugal compressor, reverse-flow annular combustion chamber and single-stage turbine. Overall diameter, 22.5in; length, 34.8in; dry weight, 194 lb; mass flow, 11 lb/sec; pressure ratio, approximately 4:1; maximum thrust, 716 lb at 25,000 r.p.m.

4002. It was logical that Fiat should have chosen a simple, "rugged" low-thrust turbojet as the subject of their first essay into the field of gas-turbine development. Such a unit should pose relatively few problems and, as Fiat have striven to make the 4002 straightforward and trouble-free, the engine may well find markets in several branches of aviation, both as a primary powerplant and emergency or a.t.o. booster.

General layout of the latest version of the engine, the .001, is described in the data panel. The original 4002.000, rated at 595 lb thrust and weighing 220 lb, was described in our 1956 aero-engine review. No attempt has been made to minimize diameter, and downstream of the compressor are both radial and axial diffuser sections. To the magnesium-zirconium intake casting is attached a variety of accessories within the diameter of the combustion section, and this unit also carries the ball thrust bearing at the front of the rotating assembly.

The combustion chamber, of reverse-flow type, has appeared in several forms. Initially the configuration was can-annular, with ten flame tubes, and a later variation had a truly annular form terminated at the rear end by 12 hemispherical domes each containing a fuel nozzle. In the revised engine illustrated the whole chamber is extremely short and comprises inner and outer liners and 16 hemispherical domes inclined inwards so that the combustion gases are turned through some 160 deg to enter the turbine nozzles. Fuel controls by Air Equipement (France) feed a manifold around the jet pipe, which emerges from the centre of the chamber (Lucas controls are used on the earlier 4002.000 version). The single-stage turbine has 47 Nimonic blades retained by fir-tree roots. Among the other British accessories is a Kelvin Hughes tachometer.

JAPAN

FIVE years of effort have now been expended in the development of small gas-turbines. In our 1956 engine review we described and illustrated the Jo-1 axial engine of 2,200 lb-thrust developed by the Japan Jet Engine Company (of 1010 Tanashi-machi Kitatama-gun, Tokyo). This and more advanced units continue in an active state, but no information on their progress is available. Production is continuing on the Kawasaki KAE-240 flat-six of 260 h.p. and licence production may be undertaken on the Continental J69 and/or T51 (Turboméca designs) and other non-Japanese engines.

POLAND

MOTOIMPORT. *Motoimport, P.O. Box 365, Warsaw, Przemyslova 26.* Most notable designer of engines at present is Dipl. Ing. Wiktor Narkievicz. Before World War 2 he was a senior engineer at the Czech Avia works, and from 1940 served with No. 315 Sqn., R.A.F., and was later engaged in Britain on engine research. He returned to Poland and in January 1946 became a chief designer of the P.Z.L. aero-engine department.

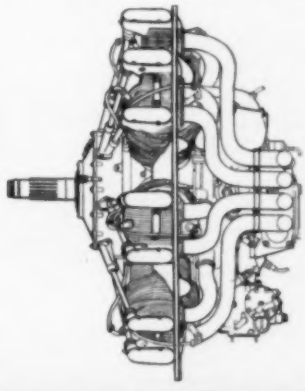
Designed by him to a government requirement, the 65 h.p. WN-1 was the first post-war Polish engine. Three prototypes gave promising results during bench and flight trials, but when the sponsor, the Department of Civil Aviation, was dissolved work on the WN-1 ceased. In 1947 the 285-h.p. WN-2 was developed to official requirements. This engine was ready for production in 1950, but, as the Polish industry was then entering an era of absolute Russian control, the WN-2 was abandoned in favour of the licence-built AI-14.

In 1952, despite an unfavourable political situation, Narkievicz prepared a study of a new engine, the WN-3 illustrated in the diagram. The prototype was completed in 1954 and was fully developed by the end of 1955. During development the maximum power was raised from 300 to 340 h.p. without increasing the weight, and the accessories are entirely of Polish manufacture. The WN-3 is in full production, principally for the TS-8 Bies trainer; some new designs, including the four-engined MD-12, will also be equipped with the engine. A special helicopter version designated WN-4 is at present flying in the Zuk helicopter, and should soon be in production.

In 1955 was completed a design study for a supercharged radial rated at 500 h.p. and designated WN-5, but this unit has yet to reach the hardware stage. The latest engine is the 180 h.p. WN-6, the prototype of which is being extensively tested and which should lead to large-scale production and long-term development, and a number of new aircraft are being designed around it. Narkievicz is also preparing a design study for a turboprop in the 1,000-h.p. class intended for a twin-engined version of the MD-12 transport.

In recent years a range of pulsejet units has been prepared under the direction of S. Wojcicki. The first model, of 22 lb-thrust, was based on the French Escopette of 1951 and was flown for the first time late in 1956. Four units were fitted in pairs under the wings of a modified Bocian sailplane. These pulsejets were later developed into units giving twice the thrust. Two more of Wojcicki's pulsejets were recently exhibited in Warsaw. Rated at 88 lb and 154 lb-thrust they were completed in 1955 at the I.L. (Aviation institute).

Poland is also licence-producing a range of Russian powerplants. Since 1955 Klimov VK-1 turbojets (Nene derivative) have been in large-scale production for Polish-built Mig-15s and 17s. Until it is replaced by the Polish WN-6 the Russian M-11FR rated at 140 h.p. at 1,760 r.p.m., and with a maximum of 160 h.p., will remain in production. The AI-14 of 260 h.p. is still being made for the Polish-built Yak-12, and the 575 h.p. AI-26 is entering production for the SM-1 helicopter.



I.L. (Aviation Institute) WN-3. Piston engine. Seven-cylinder air-cooled radial, unsupercharged and with direct drive. Diameter, 43.5in; length, 34.9in; bore, 5.31in; stroke, 5.27in; swept volume, 820 cu in; dry weight, 530 lb; maximum (5-min) rating, 335 h.p. at 2,500 r.p.m.; cruising rating, 237 h.p. at 2,100 r.p.m. with s.f.c. of 0.48 lb/hr/h.p.

The new factory at Winterthur, Switzerland, in which Sulzer undertake licence-production of British turbojets for the Swiss Government.

AERO ENGINES 1957 . . .

SPAIN

E.N.M.A.S.A. *Empresa Nacional de Motores de Aviacion, S.A., Calle Antonio Maura 4, Madrid.* Limited production is still taking place upon the 150 h.p. Tigre G-IVB and the 500 h.p. Sirio radial, the latter being a postwar design by the former Elizalde company scheduled to power the production Alcotan twin-engine transport. During the past year E.N.M.A.S.A. have striven to take advantage of their licence to manufacture small gas-turbines of Turboméca design. Production of the Marboré is gradually being started at the E.N.M.A.S.A. plant in Barcelona and the eventual Spanish-built engine will power the Hispano HA-200-R1 Saeta. The Artouste turboshaft engine may also be manufactured for the Aerotecnica AC-13 helicopter.

I.N.I. *Instituto Nacional Industrial, Madrid.* In co-operation with Hispano Aviacion, S.A., and the Instituto Nacional de Technica Aeronautica (I.N.T.A.), this organization has been developing a turbojet in the 2,000 kg-thrust class (4,400 lb) designated I.N.I.11. In our 1956 engine review we published a provisional specification and drawing; no further information on the unit has become available since that time.

SWEDEN

S.F.A. *Svenska Flygmotor A.B., Trollhätten.* As far as is known the only gas turbines upon which this company have worked are the Ghost and Avon (referred to below) and the Stal Dovern, a native Swedish design for which S.F.A. provided assistance. It has frequently been reported that S.F.A. are engaged in the development of ramjets but no official confirmation of this has yet been made.

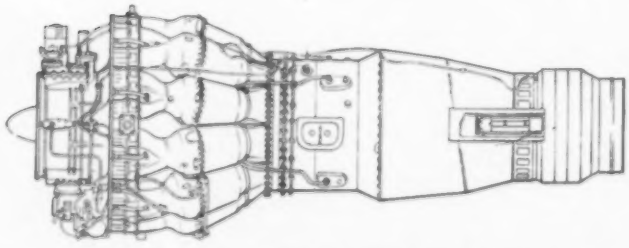
Ghost. Manufacture of the de Havilland Ghost began in 1950, under a licence-agreement with D.H. Engines. When production ceased in 1955 well over 600 had been manufactured, with the designation R.M.2.

S.F.A. have shown great skill and sound engineering in tailoring the Ghost to Swedish requirements. For the Saab-29 series of high-subsonic aircraft a special version of the engine had to be developed with a central air intake (all other fighter Ghost engines have a bifurcated intake). Most J 29, A 29 and S 29 aircraft are now fitted with the engine illustrated, which incorporates an afterburner of S.F.A. design; the control system is such that thrust is variable with reheat on.

Avon. In order to obtain a thoroughly reliable and highly developed modern axial engine in time to meet the needs of the Saab-32 Lansen programme the Swedish government decided in 1953 to purchase a licence for the manufacture of the Rolls-Royce Avon.

Designated R.M.5, the Avon 100-series, at RA.7 rating of 7,500 lb, was put into initial production early in 1955. Most of the engines so far built have been R.M.5Rs, roughly equivalent to the RA.7R and rated at 9,500 lb with afterburner. These engines are used in the Saab-32 Lansen, which is now in squadron service.

Last year S.F.A. completed tooling for second-generation Avons of the 200-series, an American report having named the models concerned as the Avon 47 and 48. No details of these engines may be published, but they probably find their nearest British counterpart in the RA.24, which is rated at 11,250 lb dry (without afterburner). The new Avon bears the Swedish designation R.M.6 and (with afterburner) R.M.6R, and it was first fitted to the J 32B advanced, all-weather Lansen which flew on January 7 of this year. The R.M.6R is also the powerplant of the Saab-35 Draken, a supersonic "double-delta" all-weather intercepter.



S.F.A. Ghost R.M.2R. Fighter turbojet with afterburner. Single-sided centrifugal compressor, ten combustion chambers and single-stage turbine. Swedish-designed afterburner with two-position, twin-eyelid nozzle. Overall diameter, 53in; length, 143in; dry weight, 2,510 lb; mass flow, 88 lb/sec; pressure ratio, 4.5:1; maximum thrust, 6,200 lb with afterburning at 10,250 r.p.m. with s.f.c. of about 2.2.

SWITZERLAND

SULZER. *Sulzer Brothers, Ltd., Winterthur.* An agreement was signed in January 1951 between the Swiss government Service-Technique Militaire and the de Havilland Enterprise covering Swiss licence-production of Venom airframes and Ghost engines. The S.T.M. delegated the work to several firms, of which the chief turbojet contractor is Sulzer, with support from Adolphe Saurer. A completely new plant was constructed for the manufacture of the Ghost and deliveries began in 1952. Over 200 Ghosts had been delivered at the beginning of the year and production is continuing. An announcement is likely to be made shortly concerning Sulzer manufacture of another British engine.

U.S.A.

AEROJET. *Aerojet-General Corpn., subsidiary of The General Tire and Rubber Co., Azusa, Cal.* Since World War 2 this company has been one of the world's major workers in the field of rocket propulsion. By far the greater proportion of their early turn-over was gained with sales of relatively simple solid-propellant a.t.o. motors, of which they have always been the world's largest commercial supplier. Today, although a.t.o. units are built in the greatest numbers, the most important programmes from the financial viewpoint are those concerning complete propulsion systems for U.S. Air Force ballistic missiles.

Their work in the a.t.o. field is conducted along classic lines for competitive business, and sales depend directly upon purchase price. During recent years Aerojet-General have striven to produce efficient and safe propellants at minimum cost, and the General Tire and Rubber laboratories in Akron, Ohio, have achieved startling results. One of the most-promising fillings is obtained by plasticizing ordinary GRS rubber with low-cost oil and then mixing it with fertilizer-grade ammonium nitrate. The resulting mix can be extruded with any desired section and yields a tough, flexible propellant at a total cost of 6 cents per lb.

A variety of solid-propellant motors is in production for primary-propulsion applications. Typical of such motors in the smaller sizes is that fitted to the Radioplane RP-70 target drone. The propellant casing is housed in the centre-body and ducts lead the hot gas from the combustion chamber to a pair of propelling nozzles in the upper fuselage decking immediately behind the trailing-edge. Another solid-propellant motor, on a far larger scale, is that under development for the propulsion of the Polaris intermediate-range ballistic missile of the U.S. Navy, under development by Lockheed's Missile Systems Division. A solid-propellant was chosen for the Polaris in order to ease the problems of handling so large a weapon on a ship at sea. The performance of the Aerojet motor is comparable to that of equivalent liquid motors, and Aerojet are well ahead with static firings of these engines at their test site near Sacramento.

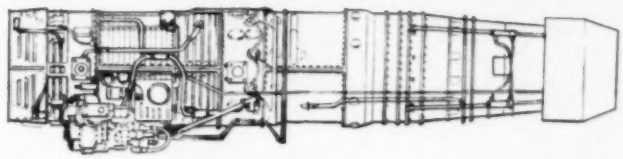
Most of the company's big liquid-propellant systems are designed to operate on liquid oxygen and kerosine. Most important of the current range of systems is that for the propulsion of the Martin Titan inter-continental ballistic missile (ICBM) to specification WS-107A. This two-stage weapon—rated the better of the two ICBMs—is propelled by single-chamber motors rated at 300,000 lb (1st-stage) and 60,000 lb static thrust. The former is the largest single chamber outside the U.S.S.R., and probably in the world. A smaller liquid-propellant motor provides boost thrust for the Boeing IM-99 Bomarc missile and is mounted on gimbals to provide control in the initial phase of launching.

Security prevents publication of details of Titan's propulsion, but an unclassified programme indicative of the company's current work on liquid motors is the second-stage motor for Project Vanguard. For this application the company have developed a 7,500-lb-thrust motor operating on white fuming nitric acid and asymmetric dimethyl hydrazine. These fluids are fed from cylindrical tanks of 410 stainless steel arranged in tandem and separated by a bottle containing warm helium at high pressure for feeding the propellants to the motor, the helium pressure being augmented by a solid-fuel gas-generator system. As far as is known, the motor will operate in the Vanguard at constant thrust, but the thrust produced can be varied by controlling the gas pressure.

Aerojet are also engaged upon the development of an air-turbo-rocket, i.e., a turbojet in which the turbine is driven by rocket combustion.

New chambers have been evolved by the Structural Plastics Division, including a lightweight chamber wrapped with plastic-bonded stainless-steel or aluminium-alloy strip. Plastics are also being investigated for the manufacture of hydraulic or propellant systems, with improvements in weight, pressure-drop and cost. Glass-reinforced phenolic and epoxy resins are stated to be capable of operating in such systems at 5,500 deg F. Aerojet are the American licencees for the S.N.E.C.M.A. thrust-reverser, which is marketed as the Aerobrake.

In production for the U.S. Navy as the powerplant of the McDonnell F3H Demon, the J71-A-2 bears little resemblance to the non-afterburning 171 depicted below. In this photograph the hot parts are covered with heat-reflecting metal foil, the propelling nozzle being on the left.



Allison J71-A-11. Single-shaft turbojet. Sixteen-stage compressor, cannular combustion chamber with ten flame tubes and three-stage turbine; variable-area propelling nozzle for establishing optimum conditions. Diameter, 47.6in overall (37in basic); length, 191in with extension pipe (172in as shown); dry weight, 4,090 lb; mass flow, about 160 lb/sec; pressure ratio, 8.3:1; maximum thrust, 10,200 lb at 6,100 r.p.m. with s.f.c. of 0.8.

AIRCOOLED MOTORS (FRANKLIN ENGINES). *Aircooled Motors, Inc., Liverpool Road, Syracuse 8, N.Y.* Since World War 2 Aircooled Motors, as manufacturers of the well-known range of Franklin engines, have become the dominant firm in the propulsion of American helicopters in all but the largest sizes. In fact, two years ago the company issued a claim that three-quarters of all the helicopters of American design then flying were powered by their engines—Bells and Hillers being predominant.

In our aero-engine review of April 9, 1954, we described the most-used helicopter engine, the 178 h.p. Franklin 6V4. The most important unit to have been developed during the past year is the "Turbosupercharged 335." Equipped with an exhaust-driven turbo-supercharger, this engine is noteworthy for its compact design; it is expected that it will be directly applicable, without airframe alterations, to helicopters at present powered by Franklin 200 engines (6V4) and that the installed weight will be only 40 lb greater. Full performance of the turbo-supercharged engine is not yet forthcoming, pending certification, but Aircooled Motors are prepared to state that it will have a minimum sea-level rating of 210 h.p. and that it will maintain this rating to an altitude of 12,000ft.

ALLISON. *Allison Division of General Motors Corpn., Indianapolis 6, Indiana.* It is no longer possible for a small or weak organization to undertake the development of advanced aircraft powerplants. As a division of one of the world's biggest companies, Allison should be placed in an increasingly strong competitive position, but their past performance has not been outstanding.

After having delivered many thousands of liquid-cooled piston engines during World War 2, the company entered the gas-turbine business in 1946 by being assigned the task of developing and producing the J33 and J35, both of which had been designed and developed by General Electric. With these two engines Allison have built up an outstanding record of production and field-service. The company's weakness—which strong measures should now have cured—has been their inability to design a competitive engine of their own.

Earliest of the home-grown Allison gas-turbines was the T38 turboprop, which was developed in coupled form as the T40 described below. This family of engines eventually led to the more advanced T56 which, as a result of protracted and painstaking development, is now serving as an acceptable and efficient powerplant in the military C-130 transport. Great efforts are now being expended in producing from it a powerplant for airline use designated Allison 501. Further-off in development is a more advanced turboprop, together with the coupled T54.

Turbojet development has been centred on the J71 engine and a special version of the J33 for the propulsion of missiles. Today large-scale development is in hand upon exceedingly powerful turbojets for supersonic applications and leading eventually to engines powered by high-energy fuels. This work is being undertaken under contract to both the U.S.A.F. and U.S. Navy, but it is reported that the company have failed to win the important contract for the WS-110A powerplant.

Putting Allison's house in order is a tremendous task which has been tackled in a most business-like manner and on a scale which few but General Motors could afford. Research and development ability has been enormously strengthened during the past 18 months both in respect of facilities and staff, and an initial outlay of $75m of G.M. money has been set aside to finance the bulk of the expansion and the initial development of four major engine projects. The company's technical staff is extremely active and is working along a broad front, but the level of production is never again likely to match that which has been maintained since 1946.

J33. A simple centrifugal engine stemming directly from the work of Whittle, the J33 was the first gas-turbine to go into production in America. It is also the only American-designed centrifugal turbojet to have gone into service. Total production is now approximately 15,000 and a fair number remain to be delivered.

Many thousands are in service in Lockheed T-33 trainers and their derivatives, and in several types of Grumman naval fighter. An overhaul period of 1,200 hr has often been achieved by these engines. More than 2,000 special J33s have now been delivered for the propulsion of cruise-type missiles, particularly the Martin TM-61 family of Matadors and the Chance Vought Regulus 1 of the Navy. Typical of the missile engines is the J33-A-37, rated at 4,600 lb at its one and only throttle opening. Without affecting reliability Allison have substantially reduced the cost of the missile engine, the main requirement specifying a total life of but five hours. A high proportion of the missile engines are shipped direct from the factory for installation and testing by enlisted men in field squadrons.

J35. A standard U.S.A.F. axial engine rated at 5,600 lb dry and 7,200 lb with afterburner, this engine remains in wide service in such aircraft as the F-84G and F-89. Total production amounted to more than 14,000 when contracts were completed in the summer of 1955.

J71. In the development of this turbojet Allison attempted to obtain a high pressure-ratio from a single-spool engine without using variable-incidence stators, and the development of the unit has been somewhat protracted. The J71 first ran in 1950.

It is now in moderately large production in two major versions. One model, the J71-A-9 or -11, powers the Douglas B-66 series of multi-purpose U.S.A.F. aircraft. Very different in appearance are the versions which are being delivered to power the McDonnell F3H Demon transonic fighters of the U.S. Navy. Typical of the fighter engines is the J71-A-2, which, with its afterburner, has an overall length of 284.6in and weighs 4,869 lb for a reheat thrust-rating of 14,000 lb. In addition to these units many J71s were installed in early SM-62 Snark missiles and a small number were built for the early Martin SeaMasters. Of these applications only the B-66 and F3H are of importance, and both aircraft will cease to be built next year.

J89. Not yet officially announced by Allison, numerous reports describe the J89 as a large high-pressure two-spool turbojet with a design-rating of 25,000 lb. Sponsored by the U.S. Air Force, it is described as "a kind of prototype" intended to lead to a unit suitable for use with high-energy fuel in the WS-110A programme. As such it is in competition with General Electric projects; and, despite a favourable technical evaluation within the U.S.A.F., the Allison design is reported to have been rejected. Were it to go forward it would do much to keep Allison working nearer to capacity.

Navy Turbojet. Since 1954 Allison have been under contract to the U.S. Navy to develop a high-pressure turbojet in the 25,000 lb-thrust class. At the time of design this was the largest projected engine in the West. A considerable amount of company money is reported to have gone into the programme but complete cancellation was reported to have taken place in the spring of this year.

Missile Turbojet. Two months ago it was unofficially stated that Allison were developing a lightweight, short-life turbojet matched to the requirements of certain species of missile. Thrust was placed in the 3,000/4,000-lb bracket and it was inferred that the engine would provide cruise propulsion for a supersonic air-launched weapon. Allison were claimed to hold a development contract.

T40. Little further work has been done on this coupled turboprop during the past twelve months. Substantial flying-time has now been logged by the T40-powered R3Y boats of the U.S. Navy and reliability is satisfactory.

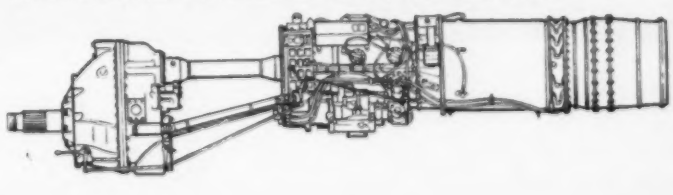
T54. Consisting of two T56 power sections coupled to a single propeller-shaft, this 7,500-h.p. powerplant is still an active project. It is scheduled to power an XF-84H test-bed, in which it will be matched with a supersonic propeller.

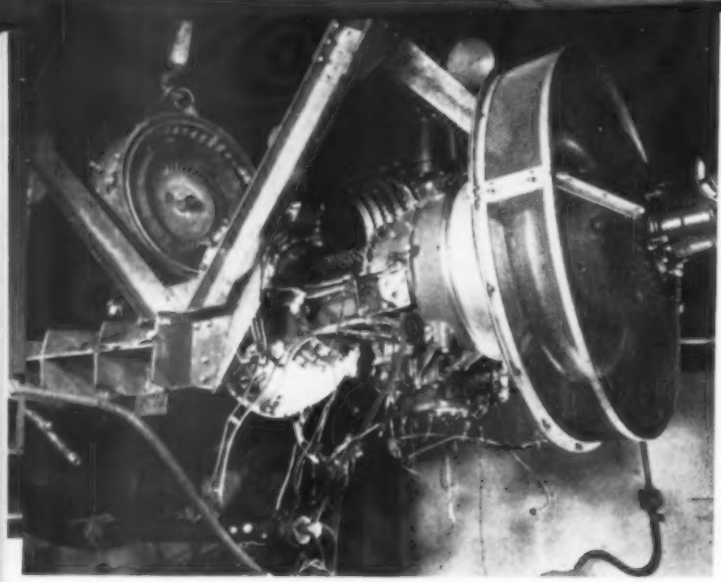
T56. During the past year this attractive turboprop has flown some 60,000 hr in the Lockheed C-130s of Tactical Air Command, and the rate at which flight-time is being increased is rising rapidly.

Its configuration is similar to that of the commercial Model 501 (illustrated) except for the location of the reduction gearbox above the propeller-shaft to permit the intake duct to lie underneath. The engine is installed as a self-contained "package" complete with 15ft-diameter Aeroproducts propeller. Flight-operations are conducted entirely at 13,820 r.p.m. with the propeller turning at 1,106 r.p.m. The single power-lever governs the fuel flow, and automatically alters the propeller pitch to suit the ruling flight condition.

Model 501. Now in an advanced stage of development, the Allison

Allison Model 501-D13. Single-shaft commercial turboprop. Fourteen-stage compressor, cannular combustion chamber with six flame tubes and four-stage turbine. Width, 27in; height, 36in; length, 145.2in; dry weight, 1,750 lb; mass flow, 39 lb/sec; pressure ratio, 9.25:1; maximum rating, 3,740 e.h.p. (3,460 s.h.p.+726 lb) at 13,820 r.p.m. with s.f.c. of 0.54; maximum continuous cruise rating at 25,000ft at 360 kt, 1,850 s.h.p.+145 lb, also at 13,820 r.p.m., with s.f.c. of 0.458.

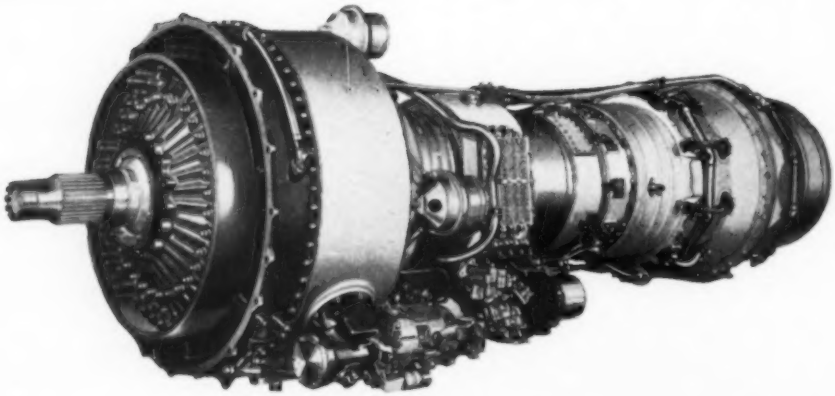




825 h.p.: First gas-turbine by Avco's Lycoming Division, the T53, here seen on test at Stratford, Connecticut, is an exceptionally versatile unit which may find many applications in fields other than aviation.

SHAFT TURBINES FOR VARIED REQUIREMENTS

Over 5,000 h.p.: Illustrated below is the extremely efficient and powerful Rolls-Royce Tyne two-spool engine, which is likely to achieve world-wide acceptance by operators of large transport aeroplanes.



3,750 h.p.: Now in operational service with the U.S. Air Force Tactical Air Command is the Allison T56 single-shaft engine (right). Driving an Aeroproducts propeller, it powers the Lockheed C-130 Hercules.

Twice 1,000 h.p.: First engine developed by G.E.'s Small Aircraft Engine Department, the T58 has a variable-stator compressor. A coupled installation has been made in this Sikorsky HSS-1 (S-58) helicopter.

AERO ENGINES 1957 . . .

501 is matched with the Aeroproducts A6441FN-606 four-blade propeller as the powerplant of the Lockheed Electra transport. Compared with the military T56, minimum changes have been made to the basic engine power-section, so that the substantial experience of the military engine shall read across as far as possible.

A major change is the adoption of a four-piece forged compressor casing, in place of the two-piece welded casing used on the T56 (higher-rated T56 engines for future production will have the forged casing). Bearing temperatures have been decreased by an external oil system, and, although not currently required for the Electra, a water/alcohol system passing 3.75 gal/hr has been developed to restore full power on a 110-deg-F day. Another feature of the Electra powerplant is special provision for reducing propeller r.p.m. to 970 to reduce noise during ground taxying; this is achieved by opening compressor air-bleeds and biassing the engine governer. The standard reduction-gear ratio is 13.54 : 1 and the complete gearbox and integral torquemeter can be packaged for shipment independently of the main power-section.

Current commercial engine is the 501-D13. On July 15 one such powerplant completed a 1,000-hr simulated airline flight-schedule on a test-bed at Indianapolis. The first certificated D13 engines are due for delivery late this year, and after approximately two years of production the more highly rated D15 will succeed it as the Electra powerplant. The advanced engine has no inlet guide vanes and transonic flow is allowed in the first three compressor stages; the turbine has increased area and shrouded blades in the first two rotor stages. These changes can be made with the aid of a field-modification kit.

Model 550. Briefly described in our 1956 review, this advanced two-spool turboprop has a design-rating in excess of 5,000 e.h.p. No further information on it has become available.

BARMOTIVE. *Barmotive Products, Inc., San Leandro, Cal.* An accompanying photograph depicts a typical Nelson flat-four of the type manufactured by Barmotive. A two-stroke unit, the Model H-63 has a guaranteed rating of 42 h.p. at 4,000 r.p.m. and under normal conditions actually gives somewhat higher power. Total displacement is 63 cu in, the width 25in and the weight, excluding carburettor and exhaust pipes, only 48 lb. The engine runs on a mixture of eight parts of 80-octane fuel to one part of oil, and the full-throttle consumption is 4.6 gal/hr.

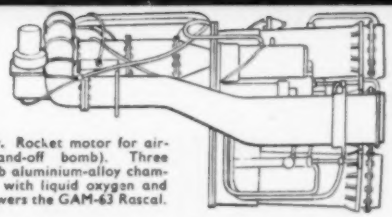
The Barmotive (Nelson) H-63 flat-four engine.

During the past year numerous detail modifications have been incorporated, among which may be mentioned increase of the bore and strengthening of the crankshaft to provide greater horsepower, and modifications to the carburettor and intake manifold to improve fuel-control and mixture distribution. The engine illustrated has a self-starter attachment. Applications include the Hiller Flying Platform, the Gyrodyne one-man helicopter and the Goodyear inflatable aircraft illustrated in our issue of June 7.

BELL. *Rocket Engine Department, Bell Aircraft Corpn., P.O. Box 1, Buffalo 5, N.Y.* Lawrence Dale (Larry) Bell, founder of the company in 1935, died last year and the new President is Leston Faneuf. Propulsion activities are the responsibility of the Rockets Division of the Weapon Systems Division of the parent corporation; the other three divisions of the W.S.D. are Guided Missiles, Avionics and Research, all of which are responsible for their own development, production and sales.

Rocket-motor development began shortly after World War 2. Since the start of operations well over 35,000 test firings have been run on complete motors or chambers utilizing more than two dozen propellant combinations. Over 50 possible propellants have been evaluated in the Rockets Division laboratories. Work is based at a large plant at Wheatfield, N.Y., on the border of Niagara Falls municipal airport, and supported by the Bell Test Center (U.S.A.F. Plant 38) nearby. Together, the two facilities have more than 50 test cells, 19 of which are equipped for environmental testing of chambers or complete powerplants at ambient temperatures from −65 to +287 deg F. Each month evaluation and production tests consume some 100,000 lb of fuel and 350,000 lb of oxidant, and the rate is increasing steadily. Employment in the Rockets Division exceeds 1,340.

After producing an earlier air-to-surface missile system named Shrike, Bell assumed complete weapon-system responsibility for the GAM-63 air-to-surface missile (what in Britain would be termed a "stand-off bomb"). This large, supersonic, winged weapon, under development



Bell Tri-barrel Motor. Rocket motor for air-to-surface missile (stand-off bomb). Three individually-fired 2,000-lb aluminium-alloy chambers fed by turbopump with liquid oxygen and kerosine. This motor powers the GAM-63 Rascal.

since 1946, is propelled by the motor illustrated in the diagram. Several important changes and improvements have been made to the GAM-63 propulsion during the past year, and these changes have involved combustion chambers, turbopump, propellant valves and tanks.

Another Bell motor is a 7,500-lb single-chamber unit operating on concentrated nitric acid. This motor originally had a possible application in the propulsion of the second-stage of Project Vanguard. It is now to go into production for installation in the tail of one of the largest mission pods—a megaton-yield delivery system—carried by the B-58. The motor is fired when the pod is released during loft-bombing, and it greatly stretches the trajectory of the pod and allows the parent aircraft to get well clear of the explosion. Like the majority of Bell motors, the chamber is made of aluminium alloy; the unit is particularly versatile and can operate on a variety of propellant combinations.

By far the largest production contracts so far awarded to the company concern the liquid-propellant sustainer motor for Nike Ajax; total deliveries of motors for this anti-aircraft missile are now measured in thousands. Operating on red fuming nitric acid, the single-chamber Nike motor is rated at 2,600 lb at 10,000ft. Superseding an earlier design, Bell's motor for the Nike is uncooled and has a chamber lined with Niafrax A ceramic. The chamber fits an envelope 6½in in diameter and 18½in long, and weighs 20 lb. Combustion conditions are 5,000 deg F and 330 lb/sq in absolute. Maximum firing time is 35 sec, specific impulse 212 and efficiency 97 per cent at 60,000ft.

BOEING. *Boeing Airplane Co., Box 3107, Seattle 14, Washington.* Development of a range of small gas-turbines continues, and production deliveries are being made to the U.S. Air Force of gas-turbine compressor carts rated at 200 air h.p. for the pneumatic starting of the B-52 and other aircraft. From the viewpoint of aircraft propulsion the latest engine is the Boeing 502-10C rated at 270 h.p. at 3,100 output r.p.m., with a continuous rating of 240 h.p. for a dry weight of 320 lb. Like its predecessors it has a single-sided centrifugal compressor turning at 36,000 r.p.m., two tubular combustion chambers and an independent power-turbine turning at 26,000 r.p.m. Compared with earlier Boeing 502 turboshaft engines it operates at a slightly improved pressure-ratio and efficiency and delivers 35 per cent more power with a 25 per cent decrease in specific consumption (to a value of unity). Other features include push-button starting, internal fuel and lubrication galleries and plain rotor bearings.

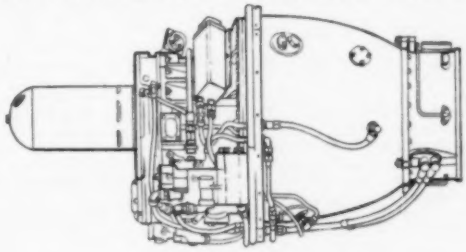
CONTINENTAL. *Continental Aviation and Engineering Corpn., 12700 Kercheval Avenue, Detroit 15, Mich.* Originally famous for their wide range of air-cooled piston engines, Continental are now also heavily committed to the development and production of small gas-turbines. Turbine work was initiated by the purchase of a licence from the French Société Turboméca in 1951. Described below are the J69 and T51, the two most important production units for aircraft propulsion stemming from this licence. In recent months the company have begun to develop gas turbines which are entirely original in conception, and a U.S. Army contract for $52,308 is held to cover a 250 h.p. turboshaft design study. Total backlog on April 30 was just over $90m.

Continental will shortly occupy the former government-owned turbine-research facility leased to Flader, in Toledo, and use the additional floor-space for continued development of the J69 and a new turboprop. In conformity with the Soc. Turboméca, Continentals are to supercharge their centrifugal compressors with a single transonic axial stage, and the new Toledo establishment will be assigned the task of perfecting the new compressors. Curiously, the improved design of combustion chamber introduced on the French Marboré has not yet been adopted for the J69.

J69. This designation applies to an Americanized development of the Turboméca Marboré, a centrifugal turbojet of 850/1,000 lb-thrust. The first production contracts were placed in April 1954 by the U.S. Air Force, and the U.S.A.F. Plant 27 (300,000 sq ft) at Toledo, Ohio, was fully tooled as a self-contained J69 production facility. After some delay deliveries in quantity began in October 1955 and many hundreds of engines have since been delivered. The production potential of the plant exceeds 100 engines per month but it is unlikely that this rate will be required.

There are at present two major variants. The engine depicted in the diagram is used in the Cessna T-37A basic trainer of the U.S.A.F. It is unfortunate that powerplant trouble caused the postponement last month of the start of the first *ab initio* jet training course in the U.S.A.F. A modification contract for the fuel control was recently awarded and

Continental J69-T-9 (Model 352). Single-shaft turbojet. Single centrifugal compressor, annular combustion chamber and single-stage turbine. Overall diameter, 22.3in; length as shown, 51.7in; dry weight 310 lb; mass flow, 16.7 lb/sec; pressure ratio, 4:1; maximum thrust, 920 lb at 22,700 r.p.m. with s.f.c. of 1.13.



AERO ENGINES 1957 . . .

a recent $9m contract will extend production to mid-1958. This month the J69 should pass its 150-hr qualification test, and a civil version will thereafter be marketed.

Continental's J69 for piloted aircraft carries the Model number 352. Model 354 is an up-rated engine with a mass flow of 19.6 lb/sec, intended for the propulsion of drones and missiles. One of the most important of this family is the J69-T-19A, of 1,000 lb-thrust, which powers the Ryan Q-2 Firebee; now on test at Holloman A.F.B. is the new XQ-2B variant in which the J69 has regularly flown at heights greater than 53,500ft. A related engine is used in high-speed target drones by Radioplane, Inc. The latest versions of the J69, and their applications, are classified.

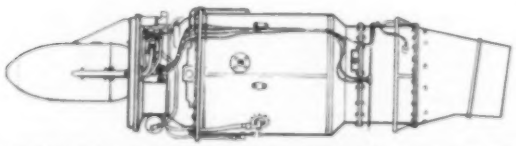
T51. In its essentials this turboshaft unit stems from the Turboméca Artouste, and it is similarly employed in various aeroplanes and helicopters. No production has yet been ordered but a variety of T51 units have flown in Bell and Sikorsky helicopters and the Cessna XL-19C of the U.S. Army. The latter Service may conceivably order the French Alouette II helicopter from Republic Aviation; should this occur Continental will produce a corresponding version of the Artouste II as the Model 220-2. Alternatively, if orders do not justify such a move, Continental would accept engines from Turboméca, convert them to U.S. Army requirements and up-rate them to 425 h.p. for shipment to Republic. Continental are also ready to tool for an engine corresponding to the Artouste III, designated Model 219; rated at 600 h.p. this would fully meet Army requirements at 6,000ft and 95 deg F. Several fixed-wing applications of the T51 are in prospect, including projected twins by Beech and Cessna.

Piston Engines. Production in the big 1.3m sq ft plant at Muskegon, Mich., is almost entirely concentrated upon flat-four and flat-six engines for a variety of light aircraft. At present Continental provide the engines for almost half the piston-engined aeroplanes built in the U.S.A. The most powerful unit is the GSO-526 which is used in the four-engined Cessna 620.

FAIRCHILD. *Fairchild Engine Division, Fairchild Engine and Airplane Corporation, Deer Park, Long Island, N.Y.* Originally an airframe company, Fairchild are now branching out into a wide range of diverse activities, not all of which are connected with aviation. Propulsion activity started in 1947 when the company initiated the design of the J44.

This unit started life as a simple turbojet for drone and missile applications, and has since been developed in versions suitable for manned-aircraft installation. To it has now beeen added a more advanced turbojet programme, the J83.

Fairchild Engine Division's research laboratories at Deer Park are specially planned for small-turbine work. The gas-turbine development laboratory, representing an investment of several million dollars, has 85,000 cu ft/min and 35,000 cu ft/min compressors, driven by a 12,000 h.p. synchronous motor, for feeding or exhausting four test cells. Under construction is a supersonic research facility. Late last month ground was broken for a 34,000 sq ft engineering building scheduled for completion on December 1.



Fairchild J44-R-20. Special-purpose turbojet. Diagonal-flow (centrifugal eye and axial periphery) compressor, annular combustion chamber with 12 burners and single-stage turbine. Basic diameter, 22in; length as shown, 88.5in; dry weight, 335 lb with basic accessories; mass flow, 25 lb/sec; pressure ratio, 2.5:1; maximum thrust, 1,000 lb at 15,780 r.p.m. with a.f.c. of 1.5. This is a "long-life" engine.

J44. First planned in 1947, this small and simple engine bears little similarity to any previous aircraft powerplant. Its monocoque construction was a particularly daring innovation. The first, short-life version was run in 1948, service-tested in 1949 and flown in a U.S. Navy missile test vehicle in 1950. Many hundreds of flights followed, and short-life versions of the J44 have been operational since February of this year in Ryan KDA-1 Firebee drones. In these aircraft J44s have flown at high subsonic speeds at up to 49,000ft, and have been operated under arduous conditions. At least one J44 has been recovered from the sea after eleven successive flights without needing overhaul or major parts-replacement.

By the end of 1952 a 50-hr pre-flight-rating test and a 12.5-hr qualification test had been completed and the J44-R-3 has now been certificated (ATC.288) as a 150-hr engine for piloted aircraft. Two of the latter were used in the first Bell experimental VTOL machine, mounted on pivots so that their thrust could be directed either downwards or rearwards. For a.t.o. assistance a number of J44s are being fitted to the wing-tips of Fairchild C-123 Providers, and T.W.A. operate a J44-assisted C-82 on European cargo services. Chief application of the missile J44 concerns Fairchild's own Petrel air-to-surface weapon of the U.S. Navy. Last December the Navy placed a $3.2m contract for J44 product-improvement and further production.

J83. Apart from the fact that the J83 is a completely new lightweight turbojet sponsored by the U.S. Air Force, very little information on the engine is available. It is rated at 2,000 lb and at present weighs approximately 300 lb—figures which do not match those established by the competing G.E.J85. Contrary to earlier reports, the first prototype was not bench-run until January of this year, but development appears to be quite satisfactory. It has been reported that Marquardt are responsible for the development of an afterburner for the engine. U.S.A.F. contracts exceed $4.6m and work is also going ahead on a commercial-transport version suitable for the Fairchild M-185 and similar machines.

FORD. *Aircraft Engine Division, Ford Motor Co., 7401 South Cicero Avenue, Chicago 29, Illinois.* With an employment of more than 12,000 and no less than 6,000,000 sq ft of floor space, this division of the Ford Motor Company is the second source for the J57 and J75 turbojets designed by Pratt and Whitney. Considerably more than 3,000 J57s have been shipped to the U.S. Air Force from Chicago, and a recent order for B-52 and KC-135 engines worth $73.6m brings the total backlog to almost $1b and will extend production into the early part of 1959.

GENERAL ELECTRIC. *The General Electric Company, Aircraft Gas Turbine Division, P.O. Box 198, Cincinnati 15, Ohio.* In 1942, a mere fifteen years ago, General Electric had never built or designed an aero engine; today their flight propulsion activities are as versatile and widespread as those of any company in the world, and during the ensuing decade they should acquire a commanding position. As the General Electric Company is one of the world's industrial giants it is possible for its aero-engine business to operate in an unusually favourable manner. Research programmes can be allowed to consume exceedingly large sums without any direct return, and facilities for research, development and production can be provided irrespective of government assistance.

During the 1930s G.E. developed and produced turbo-superchargers for piston engines, and several hundred thousand of these were built for the U.S. Army Air Force during World War 2. This experience led to the company's selection as the organization for developing and manufacturing gas turbines of basically Whittle design when the latter were introduced to America in 1942. The first engine was the General Electric I-A, virtually a Rolls-Royce Welland re-engineered to U.S. standards and with design points changed to conform to constants already established for industrial compressors. The first wholly-G.E. turbojet was the I-40 (now built as the Allison J33) and the company then boldly switched to the axial compressor. The first axial was the TG-180 (built by Allison as the J35) which was followed by the refined TG-190 which became the J47. The company also designed an unsuccessful turboprop, the TG-100 or T31.

During the past ten years G.E.'s prime aero-engine commitment has been the manufacture of the J47 in vast quantities. While this was in progress the company developed for the U.S.A.F. a large and ambitious turbojet designated J53; although successfully run at thrusts up to 23,750 lb with afterburner, no airframe application presented itself and the engine never flew. From the J47 a more advanced turbojet designated J73 was evolved; this was built in moderate quantities and is now also proving valuable as a hack in various research programmes. Later gas turbines are reviewed below. General Electric are also prime contractors in the fields of rocket motors and engines running on high-energy or nuclear fuels, and these operations are discussed under appropriate sub-headings.

A development which may find wide application is the use of engine casings made from stainless honeycomb brazed at 2,500 deg F. Another factor affecting all the company's engines is their background of experience in the overhaul of thousands of turbojets for the fighting services. They intend to maintain this work in future engines for both military and commercial operators.

Other aviation fields in which the company is working include the development of complete missile systems; guidance for the Titan ICBM for the U.S.A.F.; design and manufacture of nose-cones for Atlas and Thor, two more U.S.A.F. ballistic weapons; aircraft and missile electrical systems capable of operation at up to 500 deg C; armament systems, including the Vulcan multi-barrel gun; and such diverse fields as electronics, instruments, fuel technology, aircraft accessories and pneumatic drives, hydraulic systems and servomechanisms.

Chief of the company's flight-propulsion organizations is the Aircraft Gas Turbine Division, with headquarters at Evendale, near Cincinnati, Ohio. The Evendale plant was opened in 1948 and has since been the chief production source for aero engines, as well as the centre for design, development and testing. Automatic computers and data-reduction equipment allow the engineers at Evendale to have final results while the engine is still cooling down. An exceedingly ambitious research establishment at Evendale is now almost complete, and the A.G.T. Division's facilities now represent an investment of almost exactly $100m, with an outlay of $15m annually for expansion.

With the designation Small Aircraft Engine Department a sub-organization has responsibility for all operations relative to powerplants rated up to 7,500 h.p. or 5,000 lb unaugmented thrust, for applications in all airborne vehicles as well as marine craft, ground vehicles and transportable powerplants. The S.A.E.D. has over 6,000 employees, of which 410 are qualified engineers, and it occupies over 1m sq ft of floor in Lynn and Everett, Massachusetts, and Ludlow, Vermont. The department is at present working on numerous turbojet, turboshaft, turboprop and turbofan engines for supersonic trainers and fighter/bombers, missiles, drones, helicopters and a variety of transports.

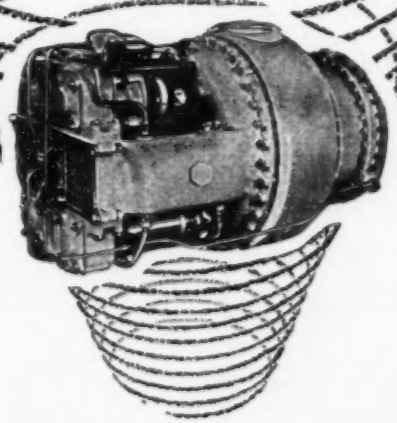
During the heyday of the J47 production at Evendale reached 900 units per month. In 1956 the plant manufactured less than 200 engines during the year, and the company are taking steps to ensure that such fluctuation—which can never be removed from all-military contracting—will not be repeated. The decision to enter the field of commercial operations was taken over a year ago and the immediate product in this field is the CJ-805 turbojet. Sales of this engine alone could never recover the investment of more than $40m which is the initial outlay involved in entering the civil market. In fact the whole of the company's flight-propulsion operations are being scheduled according to an overall study of requirements during the next 25 years.

J47. This single-shaft turbojet has been built in greater numbers than any other gas turbine. Since 1951 G.E. delivered over 31,000, and Studebaker and Packard contributed another 5,000, the majority being

THE "PALOUSTE"

SUPPLIES POWER FOR THE

FAIREY LIGHT HELICOPTER



Blackburn and General Aircraft Limited.

ENGINE DIVISION

43 BERKELEY SQUARE, LONDON, W.1

A26

This summer—
fly in Europe's newest airliner...

PARIS
BRUSSELS
AMSTERDAM
COPENHAGEN
GENEVA
ZURICH
DUSSELDORF

BEA VISCOUNT 800 now serving 12 routes

You're favoured if you fly from London to any of the places on this list. Why? Because you can make the trip in a BEA Viscount 800. And that's something to look forward to.

No journey ever went so quickly, so smoothly, so pleasantly before. Two or three hours of air-conditioned comfort—time enough to enjoy a smoke, a duty-free drink, a delicious meal—and you're there, without a care on your mind, or a wrinkle in your suit!

FRANKFURT
DUBLIN
BELFAST
GLASGOW
NICE

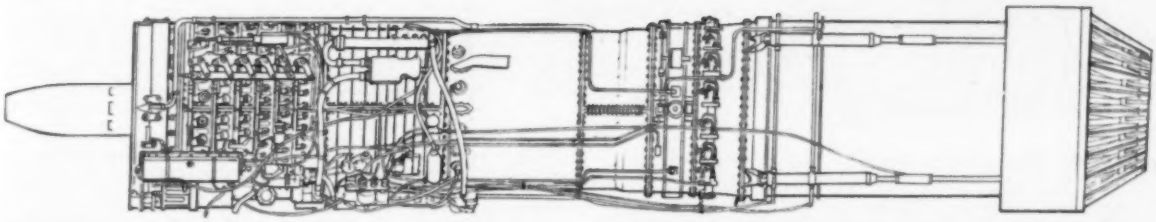
With the Viscount 700 serving 30 destinations in Europe, you can now fly BEA Viscount to 42 destinations. Full details from your travel agent, any BEA office, or BEA, Dorland House, Lower Regent Street, London S.W.1. (Tel: GERrard 9833).

BEA

VISCOUNTS FLY ALL OVER EUROPE

BUILT BY VICKERS | POWERED BY ROLLS-ROYCE

BRITISH EUROPEAN AIRWAYS



General Electric J79-GE-1. Single-shaft, variable-stator turbojet. Seventeen-stage compressor with variable-incidence inlet guide vanes and succeeding six stator rows, annular combustion chamber with 12 injectors, three-stage turbine, and high-augmentation afterburner with convergent-divergent propelling nozzle of variable throat and orifice area. Overall diameter, 32.5in (36 at nozzle); length as depicted, 204in; dry weight, 3,190 lb; mass flow, approximately 160 lb/sec; pressure ratio, approximately 12:1; maximum thrust, about 17,000 lb with reheat or 11,000 lb dry. Powerplants of this general type are fitted to the B-58, F-104 and F11F-1F.

AERO ENGINES 1957 . . .

swallowed up by such massive programmes as the F-86 and B-47. Production of this engine is an outstanding instance of faulty logistics: the life of each unit was grossly underestimated, and the U.S.A.F. had to cancel orders for some 6,000. As a result G.E. lost several hundred million dollars through making their product too reliable. Production ceased entirely more than a year ago.

Non-afterburning engines in service with Strategic Air Command total roughly 12,000, and their allowable overhaul time was raised to 1,700 hr in August 1956 and to 1,750 hr last February. Half of the engines which fail to achieve this theoretical figure are prey to foreign-body damage, and in a recent run of 4,715 overhauled only 15 had suffered corrosion. Fighter engines were still on a 400-hr basis at the end of 1956 and this figure produced a premature-failure rate of 15 per cent. At the beginning of this year the J47 had logged a total of 13m flying hours, although it is doubtful if many individual J47s had reached 2,500 hr. Hack engines are being widely used in research programmes.

J73. When production ceased last year some 2,000 J73s had been manufactured, chiefly to meet the demands of the F-86H fighter/bomber programme. Compared with the J47 the J73 compressor hub/tip ratio was reduced to increase the mass flow, and for the same reason the combustion system was changed to a can-annular configuration.

Since 1954 J73s have been extensively used as basic thermodynamic vehicles in experiments intended to determine the optimum forms of advanced powerplant for future military service. These operations are described under the sub-headings of WS-110A, WS-125A and WS-202A.

J77. As far as one can determine, this big single-shaft turbojet is the only descendant of the J53 of the 1950 era. Rated at some 25,000 lb thrust, the J77 is a long-term programme financed by the U.S.A.F. It is likely to be tied to the programmes for engines using high-energy or nuclear fuel.

J79. By 1952 G.E. and the U.S.A.F. had recognized the future need for a truly advanced turbojet capable of achieving good specific fuel consumption under subsonic cruise conditions at all altitudes, combined with very high thrust for supersonic propulsion while at the same time having minimum size and weight. In addition, the company hoped to utilize much past experience in increasing the reliability and ease of overhaul of the unit.

Two teams were assigned the task of evaluating the most likely configurations for the compressor: two-spool (or, as G.E. term it, dual-rotor) and variable-stator. After reviewing the reports of these teams the company decided to choose the latter configuration. This decision was momentous and has given G.E. a family of engines with no counterparts elsewhere. In order to achieve the required specific fuel consumption the new project required a compressor with 17 stages, and the maintenance of proper flow through a conventional compressor with such characteristics would have been impossible. Correct operation could, however, be achieved by mounting several rows of stator blades on pivots and by adjusting their incidence to keep the blade/airflow angles correct. The company proposed to use such an arrangement in their new engine, and the Air Force agreed and later awarded a development contract for an engine designated J79.

To prove the variable-stator principle the company built a demonstrator engine, which, although not of J79 size or character, was of advanced high-flow and lightweight design. It successfully proved the practicability of variable-stators, having been built in less than a year and going on the bench in 1953. At the beginning of that year actual design of the J79 began. Construction was made largely of steel, and titanium (with which the company had had unfavourable experience) was eliminated. As far as possible sheet was employed in place of cast members, to reduce both weight and cost.

The intake is of very low hub/tip ratio to provide the maximum possible airflow, and the struts and inlet guide vanes are heated by compressor-delivery air. The compressor itself has 17 stages forming a single assembly carried on a roller bearing at the front and a ball thrust-bearing at the rear. Rotor construction is entirely of steel, with blades dove-tailed into thin webbed discs through-bolted together and separated by spacer rings. Stator blading is also steel. The casing is divided into four sections, the top and bottom front casings being of magnesium alloy and the top and bottom rear casings being of steel. Like the inlet guide vanes, the first six stator rows have pivoted blades. Their incidence is changed by a linkage actuated by a ram fed—by R.700 flexible hose—with engine fuel at 3,000 lb/sq in.

To ease access most of the engine casings are split into upper and lower halves, and the combustion chamber is constructed in this manner. The chamber itself comprises an annular transition section together with ten flame-tubes each served by a single injector, interior surfaces being lined with Incoloy T (a ni-cr-ti alloy). Combustion has to be maintained over an extreme range of conditions, and relighting difficulties following flame-outs—a problem which once grounded the F-104 fighter—has been cured by a new design of G.E. dual ignition, applied to F-104 engines as an emergency modification. The turbine casings and shrouds are fabricated from precision-welded sheet-steel assemblies. The turbine has three stages and is mounted on a conical shaft splined to the rear of the compressor at the mid-point of the engine. A ball bearing is provided behind the turbine.

If an afterburner is fitted, this takes the form of an advanced high-velocity unit incorporating a new form of aerodynamic flame-holding which gives minimum drag in the dry condition. The final nozzle has multiple segments actuated through rods from four remote jacks, and in supersonic installations the area of the convergent-divergent throat can also be varied by injecting ram air through circumferential guidance passages around the periphery of the tailpipe. Augmentation ratio from the afterburner is claimed to be greater than that ever previously achieved.

The automatic control system provides for single-lever operation and is divided into "main" and "afterburner" fuel systems. Both are flow-controlling units sensitive to turbine-inlet temperature and r.p.m. The main system is integrated with the variable-stator control and much of the flight operation of the engine is conducted at constant r.p.m. Fighter engines have an additional emergency system and all supersonic J79s have a separate system controlling nozzle area. Basically the controls are hydro-mechanical with electrical trim, power for these functions being supplied by the engine. The J79 is designed to supply considerable quantities of bleed-air, and shaft drives are provided for accessories on forward and rear gearboxes, both of which are driven through a power take-off at the front of the engine.

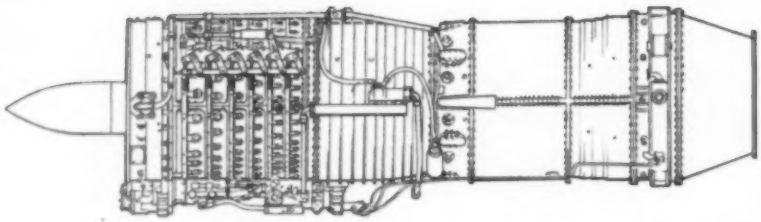
Development of the J79 has been rapid, and it took less than four years to reach full production from the start of design. The engine first ran in 1954 and flew in the summer of the following year, completing its first 50-hr test at the same time with a total bench time of but 1,600 hr. Early flying was undertaken with the unit slung below a B-45 from the G.E. air test station at Schenectady. Behaviour and reliability were so good that in December 1955 the engine was flown in a Douglas XF4D, the first time that a U.S. military engine had powered a single-engine aircraft in advance of delivery to an airframe manufacturer. The first 150-hr test was completed last August when running time had reached 6,500 hr. The engine entered full production late last year when bench and flight hours had reached 12,000, an impressive record of development which reflects the intensity of the efforts of the company and the U.S.A.F. to get the engine cleared for service.

Its first production application concerned the F-104A supersonic fighter, which first flew in February 1956 powered with the J79-GE-3. This aircraft has taken the engine to speeds higher than Mach 2. Two other applications are the B-58 and F11F-1F, which have respectively achieved sustained flight at Mach 1.9 and an altitude under power of more than 76,000ft. New families of J79 are specified for the A3J and A4H of the U.S. Navy, and for several other aircraft as well as the Regulus II missile. Particular interest attaches to the powerplant of the B-58 since it was the first gas-turbine installation intended for sustained supersonic propulsion. Each engine occupies a large nacelle of oval section, the space beneath the engine housing ducts for very large cooling airflows. The intake has a centre-body, the axial position of which is adjusted by a ball-screw ram controlled by a Minneapolis-Honeywell shock-sensing system. Supplementary intakes and heat exchangers are also provided for operation at various forward speeds.

So far the U.S.A.F. have little experience with the engine. In spite of the manufacturer's efforts to the contrary, overhauls have so far required some 2,400 man-hr; it has been reported that inspection of combustion chambers takes 40 man-hr and replacement and calibration of the main fuel control requires 80. In addition, metal bellows in the external fluid lines have been found to fail extremely frequently. At the beginning of the year engines operating on a 160-hr basis were recording a premature-failure rate as high as 50 per cent. By the end of 1960 the J79 should be on a 400 hr, 15 per cent basis, and the time should reach 1,000 hr by 1965.

J85. This extremely neat single-shaft turbojet stems from a U.S.A.F. competition early in 1954 which G.E. won. A development contract was awarded on December 14 of that year to the Small Aircraft Engine Department who have developed the engine rapidly and with high priority.

Initially there are two main families, one for piloted aircraft and the other for drone targets and missiles. Non-afterburning variants for aircraft have ratings from 2,300 to 2,500 lb, and weigh from 280 to 298 lb dry. Basic transport/trainer J85s have been selected for the four-engine configuration combat-readiness transports such as the Sabreliner and CL-329. Afterburning variants will be used in the Northrop T-38 supersonic combat and multi-purpose trainer. Missile



General Electric CJ-805. Commercial turbojet. Seventeen-stage compressor with variable-incidence inlet guide vanes and succeeding six stator rows, annular combustion chamber with 12 injectors and three-stage turbine. Diameter, 33in; length, 132in; dry weight, 2,690 lb; mass flow, about 160 lb/sec; pressure ratio, about 12:1; maximum thrust, 10,500 lb with s.f.c. of 0.8. These data refer to the CJ-805-1 only; see col. 1 below.

AERO ENGINES 1957 . . .

versions will weigh from 210 lb upwards, and will thus have a thrust/weight ratio better than 10:1, the highest announced for any gas turbine.

Numerous prototype and pre-production J85s have been built and total bench hours must be of the order of 3,000. The first 50-hr test was completed in December last year and at the end of the current year the piloted-aircraft version should be ready for a 150-hr type test. The engine has probably been flown but no announcement has been made.

CJ-805. Owing to the success of the J79 it was decided at the end of 1955 to go ahead with a commercial derivative. Initially the CJ-805 was merely a J79 without afterburner, and with a steel front compressor casing to conform to the latest airline thoughts on blade containment. Today the engine is naturally branching out along paths which differ from those of the military engine.

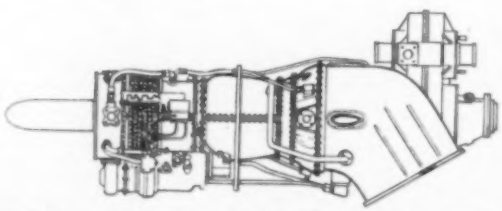
At present its only firm application is as the powerplant of the CV-880 transport. In this aircraft four 805s are mounted in individual nacelles and Convair San Diego have drawn upon the experience of their colleagues at Forth Worth with the J79 in the B-58. First contractual delivery to Convair is scheduled one year from now and the aircraft is to go into service at the end of 1959 when military J79 hours should be 300,000. G.E. have evolved noise-suppression and thrust-reversing nozzles for the Convair nacelle, which has an overall length of 138in. The thrust reverser comprises cascades through which the efflux is diverted by closing an internal clamshell. Nozzle area is tailored for minimum cruise consumption rather than for optimum t-o. thrust.

G.E. have guaranteed that the cost of replacement parts will not exceed $22 per flying hour, and the overhaul period is expected to start in 1959 at 400 hr with from 723 to 750 man-hr required for each overhaul. Already the engine is evolving into a large family, comprising the CJ-805-1; the -2 derated to about 9,000 lb; the -3 with increased r.p.m. and greater turbine-inlet temperature for the take-off rating of 11,200 lb; the -11 "growth version" rated at about 12,000 lb; and the -13 augmented version of the -11.

X-84. General Electric have studied various ducted-fan and by-pass projects during the past eight years but as far as is known this "turbo-fan" is the only currently active project. In our 1956 "Aero Engines" issue we gave the thrust as lying in the 10,000-lb class and, although the engine has not been bought in quantity, there is apparently enough U.S.A.F. support for it to be classified.

T58. Since 1954 this small turboshaft engine has been developed under Navy sponsorship as the first major assignment of the Small Aircraft Engine Department. In our 1954 "Aero Engines" issue we published a photograph of the mock-up; at that time the engine was a project study for future helicopters.

From an early stage G.E. decided to employ a high-performance compressor, with only ten stages but incorporating variable-incidence blading in the first four stator rows. By this means a fairly high pressure-ratio was achieved from a short assembly which greatly reduced the engine weight and complexity. The variable stators also eased the problems of engine control under arduous operating conditions.



General Electric T58. Free-turbine engine for helicopters. Ten-stage compressor with variable incidence on the inlet guide vanes and succeeding three stator rows, annular combustion chamber with 16 injectors, two-stage compressor turbine, single-stage power turbine and reduction gear at rear end. Basic diameter at the maximum flange, 16in; intake diameter, 11.4in; height as depicted, 27.3in; basic power-section length, 59in; length as depicted, 71in; dry weight, 250 lb or 325 lb with reduction gear; mass flow and pressure ratio, restricted; maximum rating, 1,024 s.h.p. (1,050 without reduction gear) at 19,500 power-turbine r.p.m.; maximum continuous cruise rating, 875 s.h.p. with s.f.c. of 0.69.

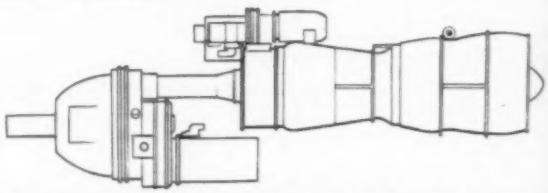
Accessory power is extracted at the front end and led to a gearbox on the underside. The compressor turbine has two stages and is cooled by bleed-air. Shaft power is extracted from a mechanically independent single-stage turbine coupled to a reduction gear bolted to the rear of the turbine casing and equipped to drive an output shaft facing to the front or rear. A worm gear drives the governor and tachometer-generator. The combustion system is truly annular and is contained within a casing split into upper and lower halves. Sixteen fuel nozzles (8 on each of two manifolds) are mounted on the front of the inner liner, and ignition is provided by a single capacitor-discharge igniter. The final exhaust trunk can be turned to leave the engine on either side or below. Three-point suspension is provided and the unit can be mounted at any angle.

As in the case of the J79, most operational running is conducted at constant r.p.m., although this may not be characteristic of variants developed for fixed-wing aircraft. All control functions are handled by an integrated system incorporating auto-fuel-metering and interlinked variation of stator angle by a single fuel-operated ram. The design objectives of not more than 4 per cent loss in output r.p.m. and a time lag of not more than five seconds under a suddenly applied load have been bettered. At military power both engines of a twin installation deliver full s.h.p., and at lower throttle-settings increased helicopter collective pitch results in less than 20 per cent differential in load-sharing.

Some dozens of 58s have been built and the engine is in the pre-production stage. The first prototype ran on April 5, 1955, and total bench time is approximately 4,000 hr. The first 50-hr test was completed early last month, and test experience includes 185 hr continuous running, 150 hr cyclic and 27 hr at military power; some parts have been tested to as much as 400 hr and turbine blading has demonstrated a life of 2,500 hr. In March icing trials began on the 6,000ft summit of Mt. Washington at −20 deg F, and the engine is shortly to be tested in the Navy laboratory at Philadelphia at from −65 to +130 deg F at simulated heights up to 30,000ft. In general performance is good, but development troubles have by no means been overcome.

The engine first flew on January 30, as a twin installation in a Sikorsky HSS-1 (S-58), and this aircraft has now logged over 100 hr of tied-down and flight development. Another twin installation has been made in a Vertol H-21D, the Navy having undertaken this on behalf of the Army who are the sponsors; this aircraft should have flown last April but has not yet done so. The engine is specified for the Kaman HU2K-1, the N.A.A. Columbus high-altitude observation aircraft, and for versions of the Bréguet 941, H.P. Herald and S.N.E.C.M.A. coleopter. Variants are intended for non-aeronautical applications.

T64. In 1955 the Small Aircraft Engine Department were awarded a U.S. Navy development contract for a turboshaft engine in the 2,000-3,000 s.h.p. bracket. The contract was probably unique in that it specified two units, a turboshaft engine and a turboprop, utilizing the same power section.



General Electric T64. Turboshaft engine for fixed-wing aircraft or helicopters (former version is shown). No information has been released on this engine, apart from the fact that the rating will start at approximately 2,600 s.h.p. and that the weight will be approximately 700 lb (presumably without reduction gear).

To achieve the low s.f.c. specified, a fairly high pressure-ratio was chosen, and the compressor accordingly has a single spool operating at up to 11:1 and with variable stators in the early stages. The combustion system is of the high-intensity pattern used in other recent G.E. turbines, and the power turbine is mechanically independent.

The engine has not yet run as a complete unit but development is otherwise well ahead. The basic power section is convertible to a turboshaft engine by the addition of a remote reduction gear, driving to the front or rear, together with largely automatic helicopter controls and a torquemeter. Conversely, the turboprop has a two-stage reduction gear together with a propeller brake and an interchangeable control package. All versions are designed for installation at any angle from three-point suspension.

In May the Navy placed a further contract valued at no less than $58.5m, and development is well up to schedule. Chief applications are described as helicopters, A.S.W. aircraft, convertiplanes and military cargo aircraft. A commercial version is also being developed.

WS-110A. This U.S.A.F. specification describes a bomber capable of long-range operation with a "dash" performance of Mach 3 or 3.2. For this application General Electric have studied turbojets representing the practical limit of what can be achieved with hydrocarbon fuels, and they now hold the prime development contract for the powerplant for this weapon system. The engine began as an extension of the advanced J79 with afterburner, but designed for substantially increased speed and altitude. Tentatively designated X-48 by G.E., the powerplant has not yet been formally sized—mass-flow determination is awaiting an evaluation by the airframe makers—but currently has a dry rating of 16,000 lb. The eventual engine is to be delivered to Boeing or N.A.A. by 1959 on a 50-hr basis.

Several J47s have been used as thermodynamic research vehicles, some having turbine blading of solid molybdenum forged by G.E. at Lynn and given a special (non-ceramic) coating by the A.G.T. Division's metallurgical laboratory. With extra cooling-air and oil feeds these engines have operated at turbine-inlet temperatures of 2,000 deg F, simulating a Mach number of 3. Tailcone and jet-pipe temperatures have exceeded 1,650 deg F. So far little work has been done on new fuels, the increased temperatures being achieved by injecting additional hydrocarbon fuel.

WS-125A. This U.S.A.F. specification concerns a nuclear bomber aircraft with a cruise endurance measured in days, even with protracted supersonic operation. G.E., who have extensive industrial nuclear experience, are one of the two prime powerplant contractors for this system, and are teamed with Convair San Diego, who are responsible for the airframe.

The company are working on an open-cycle layout, the closed-cycle system having been assigned to Pratt and Whitney. Air from the turbojet compressor is passed through the reactor itself, so forming a compact heat-exchange system which eliminates intermediate systems involving special liquids or gases. The resulting powerplant should be appreciably lighter and more powerful than corresponding closed-cycle units.

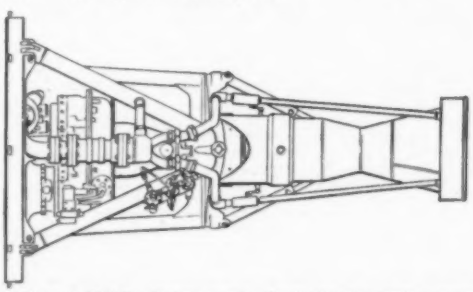
G.E. have been concentrating on systems in which a single reactor provides heat for multiple turbojets. Most rig-running has been carried out with a quartet of hack units comprising the compressor and turbine sections of J73s with the combustion systems removed. The J73 cluster is disposed around the reactor and coupled to it by ducting so that air from any one compressor is led through an individual path within the reactor and then admitted to the nozzles of the turbine of the same engine. At the A.E.C. testing station at Arco (Idaho Falls) this cluster has conducted 600-hr runs at t-i. temperatures of 1,400 deg F (implying about 1,800 within the reactor). Assuming maximum r.p.m. one derives a mass flow of 600 lb/sec and a theoretical thrust of some 35,000 lb.

This work is obviously far removed from any powerplant capable of installation in a supersonic aircraft. From it is being evolved the X-211 open-cycle system which is intended for use in the first aircraft built to the WS-125A specification. As the aircraft design is obviously completely dependent on that of the powerplant, work on the airframe side of the project has recently been decelerated. G.E., however, are in a strong position, since X-211 has been awarded more than half of the $200m which remain to be spent in this field in the current financial year. The strength and pace of X-211 development is being increased by transferring men from conventional turbine work.

Additional to this work Convair themselves have for many months been flying a 1-MW research reactor in an NB-36 aircraft. This programme is intended to evaluate materials in radioactive environments and test the shielding of structures, crew and systems.

WS-202A. Under this specification, issued by the U.S.A.F. last year, North American Aviation are developing a long-range piloted intercepter for service from 1965. Initially it will operate at Mach 5 at 200,000ft, and (it is said) the final vehicle is intended for flight at Mach 10 at some 550,000ft. The first generation of this family will have air-breathing powerplants (probably four) developed from the engines of the WS-110A. High-energy chemical fuel will probably be used from the start, and flow-velocity and temperature will far exceed anything previously associated with gas turbines.

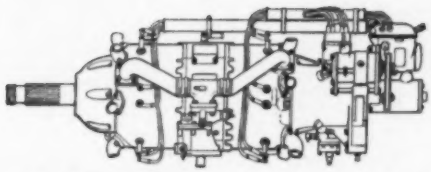
Rocket Motors. A pioneer in the field of large rocket motors, G.E. have several important contracts for the propulsion of test vehicles, a typical research programme being that of the RV-A-10 for the development of very large solid-propellant motors. Large G.E. rocket motors are proved at the Malta test station, N.Y.



General Electric X-405. Rocket motor. Single-chamber rocket motor for propulsion of first stage of Vanguard satellite-launching vehicle. Gimbal-mounted chamber fed by turbopump with liquid oxygen and petrol (with alcohol and silicone-oil added). Length as depicted, approximately 70in; thrust, about 27,000 lb; specific impulse, about 240; efflux velocity, about 7,780ft/sec.

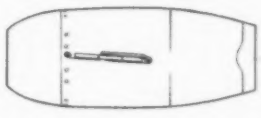
One of the biggest commitments is the propulsion of the first stage of Vanguard, the 72ft, 11-ton vehicle which will launch the earth-satellite for the International Geophysical Year. Development of the X-405 motor has posed arduous problems; during the early stages last year failures were frequently caused by the long burning time and it was rare to obtain more than 70 sec operation. The specified burning time is 141-150 sec. The motor runs on the unusual combination of liquid oxygen and a mixture of approximately 95 per cent petrol, four per cent alcohol and one per cent silicone oil for cooling. It has been suggested that later versions of X-405 may employ liquid ozone as the oxidant, but in view of the tight development schedule this could hardly be introduced at present. The motor has now reached the flight-test stage and should be highly developed by the end of the year.

HERRMANN. *Herrmann Engineering Co., 1405 Air Way, Glendale 1, California.* Extraordinarily simple in design and likely to develop into a reliable aircraft engine worthy of serious attention, the cam engine under development by this company has now been issued with an Approved Type Certificate by the C.A.A. The principal features are described in the data; extensive bench testing has been done and the company are in a position to attract sales. Since the completion of type-tests the compression ratio has been increased to 9 : 1 and 225 h.p. is being achieved; changes in timing and intake-valve size are expected to bring this up to at least 250 h.p.



Herrmann Model 375. Cam engine. Twelve cylinders housing six double-ended pistons located by rollers on a swash-plate cam on the main shaft. Poppet valves actuated by cams on the main shaft. Diameter, 18in; length, 50.5in; bore, 3.25in; stroke, 3.75in; swept volume (four strokes per revolution), 373 cu in; dry weight, 264 lb bare, 337 lb with dual ignition, starter and generator; maximum rated power, 210 h.p. at 1,900 r.p.m. Progressive increases in power are anticipated.

HILLER. *Hiller Helicopters, 1350 Willow Road, Palo Alto, Cal.* For seven years Hiller Helicopters have been developing small ramjets for helicopter tip-drive applications. The unit depicted in the drawing is fully certificated; the life is at present more than 150 hr and production units power the Hiller H-32 light helicopter. Hiller are also anxious to licence-produce S.N.E.C.M.A. pulsejets for use by the U.S. Army in such unusual tasks as lifting bridge-sections into position.



Hiller 8RJ-2B. Subsonic ramjet for helicopter tip-drive. Simple steel-sheet duct with central injector and flame-holder comprising radial, rearward-sloping fingers. Overall diameter, 8.4in; overall length, 21.2in; weight, approximately 12.7 lb; typical thrust at 662ft/sec, 39 lb; overall s.f.c., 10.2.

LYCOMING. *Lycoming Division, Avco Manufacturing Corporation, 550 S. Main Street, Stratford, Conn.* Concentrating on air-cooled engines of relatively low power, this company have built up a high reputation during their 29 years in the aero-engine business. Many thousands of piston engines have been manufactured for aircraft, helicopters and a variety of ground applications, and the company are now entering production with the first of a family of versatile small shaft-turbines. As the latter are having to compete directly with reciprocating engines, Lycoming have had to evolve a formula for minimizing the cost of design, development and production while allowing each powerplant to retain sufficient flexibility for it to be acceptable over a wide range of aeronautical and surface applications. The company have undoubtedly succeeded in this task and have broken new ground in so doing.

Development and manufacture of a wide range of flat-four and flat-six piston engines is proceeding intensively, and a completely new unit is described below. In addition, Lycoming have for several years licence-produced the Curtiss-Wright R-1300, rated at 800 h.p., and the R-1820, rated at 1,425/1,525 h.p. The former, a seven-cylinder supercharged unit, is mounted diagonally in late-model Sikorsky S-55 helicopters and horizontally in the Vertol HUP-4. The latest R-1820s have many applications, including the Vertol H-21 and Sikorsky S-58 helicopters (in all their variations) and are also used in the Grumman Albatross and S2F/TF/WF series of aircraft as well as in the North American T-28, Hurel-Dubois H.D.34 and the Learstar. All responsibility for these engines in the U.S.A. is now vested in Lycoming.

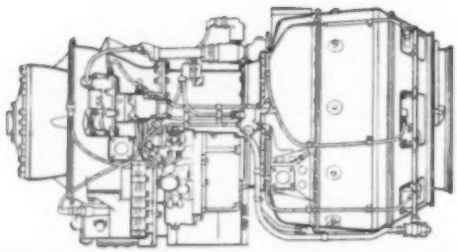
Since last Iear's review of their work, Lycoming have flown their first gas-turbine, the T53, and have announced the more powerful T55. The Gas Turbine Department has grown to a personnel strength of more than one thousand and is steadily acquiring additional space and equipment. Across the street from the main plant is the company's flight test establishment at Bridgeport municipal airport. Here Lycoming are conducting their own trials of the T53 in a Kaman HOK-1 helicopter, the work being carried out under contract to the U.S. Army. The flight test establishment will also be used for fixed-wing engine development. Another new facility for which ground has been broken is the model engine service centre located at the airport at Williamsport, Pa., which is believed to be the only centre of its type in America devoted to small aircraft engines.

Apart from engines, the Lycoming Division's aviation activities are varied and well established. Sub-contract work, a major part of their business, has been progressively expanded during the past twelve months. One of the most interesting contracts concerns the manufacture of the 48in nozzle housing for the Curtiss-Wright RJ47 ramjet, powerplant of the Navaho. The first units to this contract were delivered last winter. Other work includes the design and development of parts for B-50 tanker conversions, major components of the air-turbine-driven alternators and hydraulic packs of the B-52, precision-machined parts for the J57, J75 and J79 engines, hydrospin components for guided missiles, precision-machined parts for Sikorsky helicopters and manufacture of the bulk of rotor components for the Vertol H-21.

Total Lycoming employment at their two plants at Stratford and Williamsport is approximately 9,000. A new divisional president, James R. Kerr, was appointed on May 1 of this year.

T53. Vice-president (turbine engineering) of Lycoming is Dr. Anselm Franz, who until 1945 was responsible for the design of gas turbines for Junkers A.G. Now an American citizen, Dr. Franz gathered a staff of six at Lycoming and in 1951 began to investigate the general field of small shaft-turbines. Early in 1952 a design-study was submitted to meet a joint Army/U.S.A.F. requirement for a "flexible" turboshaft engine of 600 h.p., principally for helicopter applications.

It was no mean achievement for the embryonic team at Lycoming to win the competition in July 1952, against 13 other companies. In spite of their lack of experience and facilities the Lycoming team, which had then grown to 25, began parts-fabrication in the summer of



Lycoming T53-L-1 (LTC1B-1). Free-turbine engine for helicopters or fixed-wing aircraft (the former version is depicted). Compressor with five axial stages and one centrifugal stage, annular combustion chamber with 12 vaporizing burners, single-stage compressor turbine and single-stage power turbine. Diameter, 23.25in; overall length, 47.8in; dry weight, 460 lb; mass flow, 10.8 lb/sec; pressure ratio, 5.7:1; maximum rating, 825 s.h.p.+102 lb thrust at 21,500 r.p.m. (6,790 output r.p.m.) with s.f.c. of 0.673 lb/hr e.s.h.p. The fixed-wing engine gives 808 s.h.p.

AERO ENGINES 1957 . . .

1953. The gas-producing part of the T53 engine went on test in December 1954, and at U.S.A.F. request was then up-rated to 720 h.p.

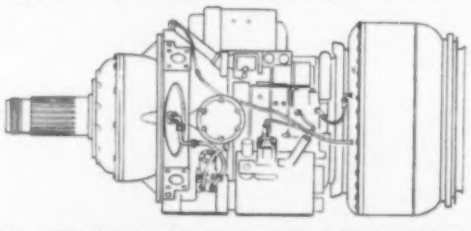
Unlike all previous American aero-engines, the T53 is a free-turbine unit, and it is largely this feature which has conferred upon the engine the valuable quality of being able to operate over a wide range of r.p.m. at constant torque or power, or alternatively to maintain constant r.p.m. over a wide range of power. To the basic gas-generator section can be added gearboxes and other equipment suitable for helicopters or fixed-wing applications.

From the annular intake the air is compressed initially in an axial unit comprising five stubby discs with inserted swallow-tail-root blades of 405 stainless steel. From the outset the stators have been manufactured (at 35c apiece) from twisted sections of rolled aerofoil strip. An axial rotor has now also been run with similarly fabricated blades for a period exceeding 300 hr, and it is expected that the price per blade will be reduced by this method from $14.5 to $1.5. Behind the axial assembly is a single-sided centrifugal impeller fabricated from 422 stainless steel (a titanium impeller is at present under test and this saves 11½ lb in weight and reduces acceleration time).

Final radial compression obviates the need for the tiny and delicate axial blades which would otherwise be required, and it also throws the air out to a diameter suitable for the combustion section. The latter is truly annular and comprises inner and outer liners so arranged that the air first passes just inside the outer casing of the engine to the rear of the chamber where it is turned through 180 deg and flows forwards through the primary zone. Fuel is injected at the rear of the chamber through twelve "walking stick" vaporizing burners reminiscent of those of Armstrong Siddeley. A proportion of the compressor-delivery air does not enter the chamber at all but is directed around the forward end by peripheral cascades to form a secondary flow of dilution and film-cooling air.

In the space in the centre of the annular chamber are located the compressor turbine and power turbine, each of which has a single row of cast blades. The design of the chamber is such that temperature distribution is very even around the turbine inlet, and the T53 has been run at mean gas temperatures of 1,700 deg F. Moreover the fact that the turbine wheels are surrounded by four layers of steel shielding is considered a valuable safety feature; during the development of the T55 (*q.v.*) malfunction of their locking device allowed ten turbine blades to slide out of their fir-tree roots and leave the wheel entirely, but none penetrated to the outside of the engine. The folded configuration of the combustion chamber appreciably reduces the length of the engine, a factor which was of assistance in easing the whirling problems of the power-turbine drive shaft. Another advantage of the layout is that, since the power-turbine is supported within the exhaust diffuser, which is itself part of the combustor, the whole power-turbine and combustion-chamber assembly can be removed as a unit to expose all the hot parts of the engine. This can be done even with the unit installed in an airframe.

Total bench testing amounted to 2,000 hr late in January and is now probably double this amount. The 50-hr preliminary flight rating test was passed last August and several YT53 engines have been delivered. Last September a T53 was run in the HOK-1 test-bed, and after approximately two hours of ground running this helicopter flew on September 27. On October 20, after several hours of ground running, the new Bell XH-40 helicopter was flown for the first time. Both these helicopters have since shown that the flight behaviour of the T53 is exemplary. It is worth noting that at the mock-up review of the H-40 the T53 was removed and replaced in fifteen minutes. The engine is also flying in the Vertol 76, in which it drives two lifting/propulsion rotors and two ducted torque-control fans. Future applications of the engine include the Grumman high-performance observation aircraft (a development contract was placed earlier this month for the fixed-wing T53) and several other machines.



Lycoming T55-L-1 (LTC4A-1). Free-turbine engine for fixed-wing aircraft or helicopters (the former version is depicted). Configuration similar to that of T53, above. Diameter, 24.25in; overall length, 58.854in; equipped dry weight, 695 lb; mass flow and pressure ratio, restricted; maximum rating, 1,500 s.h.p.+378 lb (1,651 e.h.p.) at 1,290 output r.p.m. with s.f.c. of 0.657. The helicopter LTC4B-1 gives 1,600 s.h.p. and weighs 600 lb.

T55. Unlike reciprocating engines, gas turbines are amenable to being scaled up or down, and when a company has developed a successful unit it is logical to produce the same design to a different scale to meet a wider field of applications. In the T55, Lycoming have produced an engine which, although substantially similar to the T53 in its dimensional envelope and only some 18 per cent heavier, gives double the power with better specific fuel consumption.

In basic layout the new T55 is identical to its predecessor, although the design points are slightly more ambitious. The U.S.A.F. requested Lycoming to develop the engine and it is now being funded by the U.S. Army. Like its predecessor it is available in fixed-wing and helicopter versions, and with slight modification can be adapted for marine or industrial use.

Prototypes have been subjected to extensive testing and the engine has a number of civil and military applications. Two recent four-engined aircraft which are being planned around the engine are the Fairchild Turboboxcar and the Douglas 1906/1940 series.

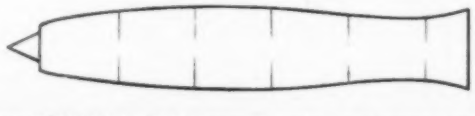
Piston Engines. Four of the well-established flat-four units manufactured at Williamsport are the O-235-C1 (108 h.p.), the O-290-D2B (135 h.p.), the O-320 (150 h.p.) and the O-340 (170 h.p.). To this range has now been added a new engine with the highest rating of any certificated four-cylinder engine produced in the U.S.A. Designated O-360, the new unit is rated at 180 h.p. at 2,700 r.p.m. and has a very competitive power/weight ratio. The O-360 uses 91/96-octane fuel, and has salt-cooled valves of the rotator type, chrome piston rings and a nitrided crankshaft; an optional item is a constant-speed unit. The engine has powered the prototype Piper Comanche and is the standard powerplant of the Beech Travel-air.

Among the flat-six engines are a variety of helicopter units, such as the VO-435 of 260 h.p. used in late-model Bell helicopters, and the 340 h.p. GSO-480 supercharged and geared engine which powers the Super Aero Commander.

MARQUARDT. *Marquardt Aircraft Company, 16555 Saticoy Street, Van Nuys, Cal.* Founded by Roy E. Marquardt 13 years ago with $1,000 capital, Marquardt Aircraft is now selling at the rate of many millions of dollars annually. The vast majority of the company's work lies in the field of supersonic ramjets, but it can now be said that Marquardt operations encompass every type of advanced air-breathing powerplant—and some engines which are only partially air-breathing.

One of the three partners in the OMAR group, the others being Reaction Motors and Olin Mathieson, Marquardt have now taken their first supersonic ramjet families to the production stage and on June 4 dedicated an *ad hoc* production plant at Ogden, Utah. The most important unit in this connection is the RJ43, described below.

Subsonic ramjets include a variety used for drone and test-vehicle propulsion, as well as a range of helicopter tip-drive devices. Among the latter are ramjets of aerofoil section forming extensions to the rotor blades. A great deal of work has been expended in the development of afterburner systems for several turbojets designed by other companies, a recent programme in this field concerning the Fairchild J83. Marquardt are named as a prime contractor to the U.S. Air Force in the Aircraft Nuclear Propulsion Program, and it is unofficially claimed that they are well advanced in the design of a ramjet drawing heat from nuclear fuel "although," says the report, "the project was not in the hardware stage last April." Yet another advanced project upon which Marquardt are working concerns an air-turbo-rocket, i.e., a turbojet in which the compressor is driven by a highly rated turbine fed with gas from a controlled-combustion solid or liquid charge. Since turbine output is thus made independent of air density much greater thrust can be obtained at altitude than from a normal turbojet, and, in addition, hydrocarbon fuel can usually be burnt in the rocket exhaust to give augmented thrust.



Marquardt RJ43-M-1 (MA-20C). Supersonic ramjet. Fixed-geometry supersonic intake, centre body housing fuels system and controls, and convergent/divergent nozzle. Diameter, 28in; length, about 145in; dry weight, 485 lb; mass flow and pressure ratio, restricted; maximum theoretical thrust at sea level, about 11,500 lb.

RJ43. Depicted in the drawing, this is the largest supersonic ramjet yet to have been built in really large numbers. Bearing the company-designation MA-20C it has a diameter of 28in and in its first generation burns conventional kerosine fuel.

The double-shock intake is very accurately made and has a fixed geometry. Most of the fuel system components, including the ram-air-turbine fuel pump and the control system, are assembled and calibrated on the bench in self-contained pre-programmed packages which can be readily installed or replaced in the field. Flame-holding is accomplished by an efficient mechanical system, although no doubt aerodynamic means will eventually be incorporated. The combustion chamber is lined with a thick coating of aluminium oxide and the carcase of the engine includes such new alloys as HK31 (Mg-Th-Zr), A-110AT (ti) and 6Al-4V (a self-explanatory heat-treated ti-alloy).

For several years the RJ43 has been the powerplant of the IM-99 Bomarc twin-engined anti-aircraft missile of the U.S. Air Force. Flight development has been conducted very successfully with the Lockheed X-7 test vehicle, which has also been used to develop Marquardt's larger 36in ramjet. Preliminary flight-rating test funds included $5m in the spring of 1956; two months ago the Air Materiel Command placed a $1.66m contract for RJ43 production testing.

NORTH AMERICAN. *North American Aviation, Inc., Rocketdyne Division, Canoga Park, Cal.* Since 1946 this giant among the world's aircraft companies has been heavily engaged in the design, development and production of liquid-propellant rocket motors of very high thrust. The result of their work to date is summed up in a single sentence from the company's last annual report: "Rocket engines were produced . . . for most of the nation's presently programmed intercontinental and intermediate-range missiles."

Rocketdyne, the division responsible for this work, has steadily expanded at Canoga Park, and its development and manufacturing strength, already considerable when we wrote our 1956 review of engines, more than doubled during the 1956 fiscal year. Additional large test stands and supporting buildings were commissioned at the division's propulsion field laboratory in the Santa Susana mountains. Very soon Rocketdyne will occupy a $13m government-owned production plant nearing completion at Neosho, Missouri. Some 650 employees have been assigned to work at Neosho, and the number should reach 1,500 in January. Total Rocketdyne employment on September 30, 1956, was 6,800.

A licence was recently obtained for the production of IDIOT, or instrumentation digital on-line transcriber, from Minneapolis-Honeywell. This equipment has been used by Rocketdyne for the simultaneous reduction and recording of up to 128 "bits" of data during test-firings, and its manufacture marks a broadening in scope of the division's operations.

Major programmes for which Rocketdyne holds propulsion responsibility include both the ICBMs, Convair's Atlas and Martin's Titan, as well as the two land-based IRBMs, the Army Redstone/Jupiter and the Air Force Douglas Thor. For Titan, Rocketdyne are clearly either in competition or in partnership with Aerojet-General. For Atlas the B-2C powerplant was evolved, which, like nearly all the big Rocketdyne motors, operates on liquid oxygen and petrol. The missile has one sustainer of 135,000 lb thrust and two-self contained sustainer pods each rated at either 60,000 or 100,000 lb.

Most important production unit, however, is the S-3 motor, rated at 150,000 lb. This is the powerplant of both Jupiter and Thor, and until recently was the unit with the highest rating of any single-chamber motor. Three essentially similar chambers combine to provide from 405,000 to 450,000 lb thrust for 45 sec to accelerate the SM-64A Navaho up to the Mach-2.7 speed at which its ramjets will light up. Unfortunately flight experience with Navaho—now, in any case, cancelled—has been fraught with distressing, if instructive, mechanical failures. So also has that of Thor, which has four times reached the firing pad and never yet achieved a successful flight. These are but temporary setbacks, and Rocketdyne have their finger in so many pies that they cannot fail to be in at the finish.

Under the terms of a ten-year mutual technical assistance agreement signed in 1955 data are being exchanged with Rolls-Royce. The British company is also "licensed to manufacture large, liquid-propellant rocket engines designed and developed by North American." Several new rocket applications are being investigated, including manned aircraft.

PRATT AND WHITNEY. *Pratt and Whitney Aircraft, Division of United Aircraft Corpn., 400 Main Street, East Hartford, Conn.* For many years Pratt and Whitney have been the largest aero-engine company in the world. Several hundred thousand piston engines have been made to their design—these engines provided more than half the total horsepower of all the Allied aircraft used in World War 2—and the company have today unbalanced the entire American engine industry by gaining more than 60 per cent of the total available business.

This extraordinary position has come about through the company's excellent past record of sound engineering coupled with their inherent conservatism and extreme care in planning each new design. The first advanced gas turbine of their own design (the J57, described below) appears on paper to be expensive and heavy in relation to its output yet it has for several years been the only unit capable of doing several of the most important military propulsion jobs, and both the parent firm and the Ford Motor Company (*q.v.*) are working at high pressure to deliver engines at the required rate. It is the only American engine produced by a "second source".

During the past year the company have begun the establishment of a new plant at West Palm Beach, Florida. Situated 17 miles east of the town, the new facility will be an exceedingly large and well-equipped plant for the development and testing of advanced powerplants. It will fabricate and assemble new engines on a limited scale for use in experimental aircraft, but will not undertake production. The J58 will be its first major assignment. Earlier this month the U.S. Navy awarded a $28m contract for shop and test equipment, the whole establishment being an investment of $40m.

In the last twelve months the payroll at East Hartford has risen by more than 3,500 to a total of over 40,000, the majority of the additional personnel being engaged in the production of the J57. Excluding deliveries from Ford more than 6,000 of these fine two-spool turbojets have been delivered to the Air Force and Navy and from the end of this year the company are to deliver the fully certificated JT3C commercial derivative. Backing up the J57 is the rather larger and much more powerful J75, which is already in production to meet the requirements of several important programmes of the Air Force and Navy. From early 1959 a commercial variant of this engine, also, is scheduled to be delivered against heavy orders placed by airlines all over the world. Pratt and Whitney have also had limited success with two engines originally financed by the U.S. Navy, the T34 turboprop and the J52 turbojet, and they are pressing ahead with advanced engines such as the J58 and J91.

The latter is a turbojet drawing its heat energy from a nuclear reactor, and Pratt and Whitney remain one of the largest workers in the nuclear-propulsion field. This activity is likely to provide the company with business of a very long-term nature. The company are also retaining an interest in other forms of propulsion, and are in addition finding that the reciprocating engine is dying a slow death.

J48. Ultimate development of the Rolls-Royce Tay centrifugal turbojet, the J48 has been licence-built at East Hartford since 1951. Owing to the continued production of the Grumman F9F-8 and F9F-8T the engine has remained in production much longer than was originally anticipated, but the total contracts have now been fulfilled. In its final form the J48 was rated at 8,500 lb-thrust with water injection.

J52. Development of this medium-thrust turbojet began with the receipt of a Navy contract about four years ago, funds having been transferred from the defunct T52 turboprop. In its essentials the unit is a scaled-down J57, and it introduces few novel features.

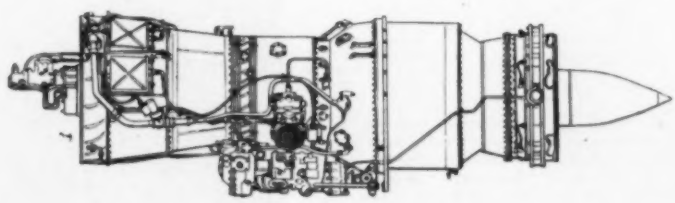
Until last year the engine had no firm application and seemed likely to die a natural death. It was, however, an obvious basis from which a commercial engine suitable for an important medium-range transport market might be developed, and the manufacturer may have brought some pressure to bear on the Navy to hasten its development. In any event, the Navy decided to purchase an afterburning version as the powerplant of the Douglas A4D-3 Skyhawk carrier-based attack bomber. Compared with earlier versions of the Skyhawk the A4D-3 promised to have substantially improved performance in all respects, since, although the Pratt and Whitney engine is larger and heavier than the powerplant for which the aircraft was designed, it has considerably greater maximum thrust and improved specific fuel consumption. The order for the J52 amounted to several hundred engines when it was cancelled earlier this month. It is unlikely that the engine will find other applications.

J57. Maintaining its position established in 1953, this high-pressure two-spool turbojet can be assessed as the most important American engine in current operation. It was Pratt and Whitney's first attempt to design a modern gas turbine and, although one could today make such a unit much lighter, simpler and cheaper, the J57 was soon established as being without any peer. It was the first turbojet in the 10,000 lb-thrust class to become available for use in the U.S.A., and this fact, coupled with its outstanding economy and reliability ensured its immediate acceptance by six major airframe manufacturers for the propulsion of the most important American bombers, fighters, attack aircraft, tankers and transports of their generation. It is also used by two more manufacturers for the propulsion of a high-altitude research aircraft and a cruise-type strategic missile. On July 1 total deliveries from Pratt and Whitney and Ford were in excess of 9,500.

When design began in 1948 the project was the only two-spool, or split-compressor, gas turbine in the world. The prototype first ran in June 1949. From that date the engine has been exhaustively developed; it has been run in the company's Willgoos laboratory under conditions appropriate to flight at 70,000ft, and has been air-tested in a wide range of aircraft. Initial flight trials took place with units slung under a B-45 and a B-50, and in April 1952 eight development engines powered the Boeing YB-52 on its maiden flight, when the engine had a special-category flight clearance rating of 8,800 lb.

Curiously, the work-split between the two compressors is such that the low-pressure front spool requires a two-stage turbine to drive it.

Pratt and Whitney J52-P-2. Turbojet with afterburner. Split-compressor (two-spool) turbojet with can-annular combustion chamber fed by 12 injectors, mechanically independent high- and low-pressure turbines and afterburner with multiple injectors and variable-area nozzle. No data on this engine are available except for the dry thrust rating of 7,500 lb and the corresponding s.f.c. of 0.8.



Pratt and Whitney J57-P-19 or -31 (JT3 is essentially similar). Split-compressor turbojet. Nine-stage low-pressure compressor, seven-stage high-pressure compressor, can-annular combustion chamber with eight flame tubes, single-stage high-pressure turbine and two-stage low-pressure turbine. Basic diameter, 40in; overall length as depicted, 180in; dry weight, 4,100 lb; mass flow, 181 lb/sec; pressure ratio, 12.5:1; maximum thrust, 13,000 lb with water injection at 8,000 low-pressure r.p.m. with s.f.c. of 0.82. With afterburner this engine can give up to 17,500 lb (s.f.c., 2.0) and weighs 5,200/5,600 lb.

AERO ENGINES 1957 . . .

The tip radius of this compressor tapers considerably from front to rear, giving the engine a wasp-waisted appearance which provides useful installational volume for accessories. The high-pressure spool is untapered along its outer diameter and both compressors are built up from centreless discs and spacers, the blades being retained by single dovetail slots broached diagonally around the periphery of each disc. The annular combustion chamber contains eight flame tubes formed from spot-welded stacks of Inconel rings. Each flame-tube forms a small-scale annular combustion chamber into which fuel is injected from six downstream-injection burners (of which there are thus a total of 48). The burners are fed by main and secondary fuel lines, the secondary circuit being brought into action at a flow of more than 2,000 lb/hr. At lower flow rates the fuel in the secondary pipes is stationary, and to avoid coking in this condition the secondary pipes are run concentrically through the centres of the primary pipes.

Several types of afterburner have been delivered for the J57, the majority giving reheat up to 2,000 deg K from multiple radial injection bars and three concentric gutter-type flame-holders, ignition usually being of the "hot-streak" pattern. Some of the more recent afterburner systems incorporate an aerodynamic flame-holding arrangement, in which high-velocity jets of compressor-bleed air are directed upstream within the afterburner. These jets create local regions of relatively dead or turbulent air in which the afterburner combustion can be maintained comfortably; in the dry condition they have far less drag than mechanical flame-holders. The propelling nozzle of afterburner-equipped J57s is usually of the two-position type. In the earliest versions, used in the F-100A, there were 24 sliding nozzle segments which were positioned by 24 separate hydraulic jacks. Current fighter engines have but eight segments hinged at their leading edges. For the F-101 aircraft a short afterburner giving a relatively low augmentation-ratio was developed, this powerplant having a length of 200in.

As a basic design the J57 is no longer representative of current Pratt and Whitney practice. Nevertheless the engine has a record of economy and reliability which is acknowledged throughout America as a target at which other companies should aim, and Pratt and Whitney's great effort with the engine has been rewarded handsomely.

Current production involves many types of J57, the majority being advanced powerplants for the B-52 and KC-135, or afterburner engines for supersonic fighters. In nearly all cases the low-pressure compressor is now manufactured almost entirely of titanium, the change both reducing the weight of the engine and increasing the fatigue-life of the blading. Discs, spacers, blades, low-pressure and intermediate casings and inlet case are all fabricated from the new alloys, and considerable flight-time has now been accumulated, particularly with alloys 150A, 140A and C-130AM. The latest engines incorporate the new PWA682 (6 per cent Al, 4 per cent V), which is reckoned the optimum available at present. As an indication of the weight-savings which have been effected, the cut-weight of the forging for the first-stage compressor disc has been reduced from 120 to 75 lb, and the utilization ratio has been improved. Typical equipment of J57s includes Holley or Bendix fuel control, Hydro-Aire pneumatic gate-valves and water-injection control, a pneumatic turbine starter and a saddle oil tank. Provision is made for bleeding air at up to 300 lb/sq in at 750 deg F.

During the past year the engine has flown at least a million hours, the majority being logged by the octets of engines flying with the 180-odd B-52s now in operation. In this aircraft the engine has a good record, and one powerplant was recently "pulled" after having been flown in a B-52 for 1,000 hr without removal. During the first year of B-52 operations with Strategic Air Command the powerplant overhaul time was 500 hr. Castle was the first base to operate the engine, and between June 1955 and August 1956, in which the aircraft strength grew from 1 to 40 machines, 81,112 engine flight hours were logged and 95 engines were removed prematurely. At the end of that period the mean achieved life was 600 hr, the failure frequency 0.28 per 1,000 hr and the in-flight shut-down rate 0.29 per 1,000 hr. A further increase in overhaul time to 800 hr was made last October and the current figure is just on 1,000. At present a major overhaul occupies about 850 man-hr (or 1,012 including accessories) and costs about $15,000.

Current B-52 and KC-135 engines are similar to that shown in the diagram, and related units are used by the U.S. Navy in the A3D. Afterburning fighter engines are generally operating on a 200-hr basis with a 15-per-cent premature-failure rate. These engines should reach a 460-hr cycle by the end of 1960.

J58. Mindful of their lack of success with another turbojet maker, the U.S. Navy have recently been placing an increasing amount of business with Pratt and Whitney. The company's largest commitment to the Navy is the J58 turbojet, which is intended to fill the rôle for which G.E.'s advanced (high-energy fuel) engines are being planned for the U.S.A.F.. It has been reported in the U.S.A. that the J58 is a high-airflow engine intended for operation at Mach 3 and sized to give 22,500 lb static thrust, conforming to the Newbury Memorandum requiring each new engine to exceed the previous generation's output by 50 per cent. Another report, however, has claimed that the J58 is an 18,000-lb engine, which would in effect make it a much lighter and more advanced unit in the thrust-class of the J75. Current J58s are designed to use conventional jet fuels, and their development and testing is being undertaken at the Pratt and Whitney facility at West Palm Beach, Florida.

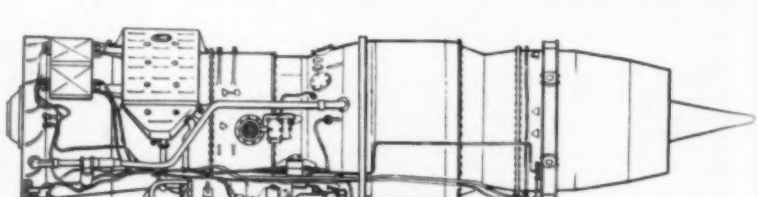
J75. In 1951 Pratt and Whitney received a U.S.A.F. development contract for a scaled-up J57 with a mass flow of 250 lb/sec. The engine first ran in 1953 at about 14,000 lb static thrust, and was then exhaustively tested in the Willgoos laboratory and flown from Rentschler Airport at the beginning of 1955, slung beneath a B-45 test-bed. During the past two years many thousands of hours of bench and flight time have been logged, and current versions already form a considerable family for a range of applications.

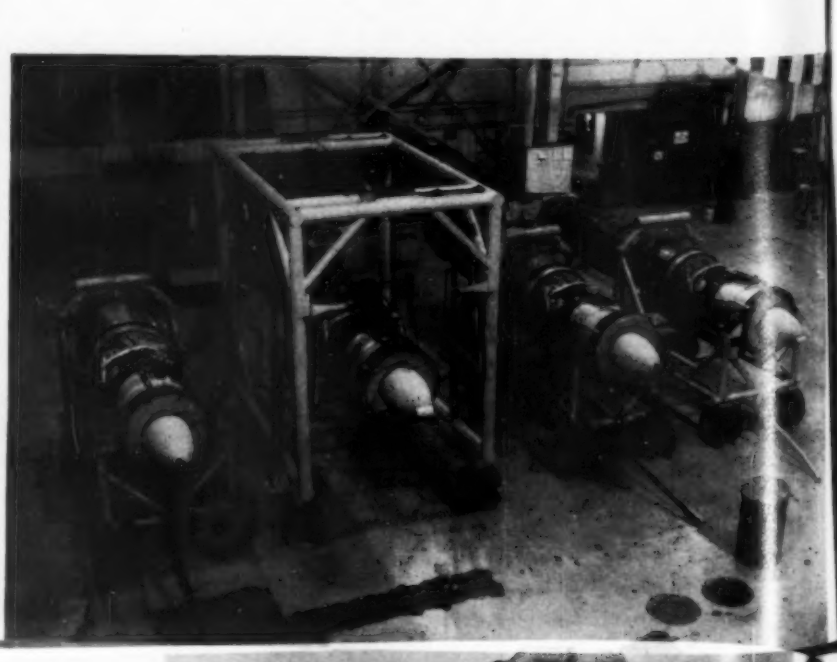
In its basic geometry the J75 is similar to the J57. Owing to its later design its increase in thrust over the earlier engine is considerably greater than the proportional increase in weight, and today's J75 is a most competitive unit, particularly for long-range aircraft which have to be capable of supersonic speed. A considerable proportion of titanium is employed in the construction of the compressor rotors and low-pressure and intermediate casings. Fighter powerplants have a large afterburner with a multi-shutter con-di variable-area nozzle.

Powerplants of the latter type are fitted to the F-105B and C, F-106A and B, and F-107, and are scheduled for the F8U-3. These large aircraft have peak level performances up to Mach 2.3, and the static thrust of their engines is approximately 24,000 lb with reheat. The J57 is about to be flown in a B-52 on endurance testing, but it is very unlikely that it will ever power a version of this aircraft. The engine has, however, been chosen as the powerplant of the Martin P6M-2 SeaMaster, which is now in production. Second-source production of the J75 is undertaken by Ford (*q.v.*) and the commercial variant is the JT4A below.

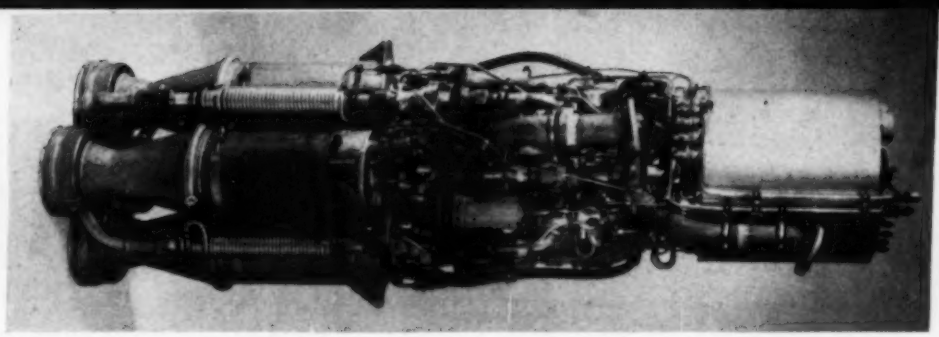
J91. As one of the two prime powerplant contractors to the U.S.A.F. for the WS-125A nuclear bomber specification, Pratt and Whitney have established an exceedingly large *ad hoc* facility known as the Connecticut Aircraft Nuclear Engine Laboratory (CANEL). Stretching for over two miles along the Connecticut river near Middletown, the plant is nearing completion and will ultimately be used as a pro-

Pratt and Whitney J75 (JT4A is essentially similar). Split-compressor turbojet. The configuration of this engine is basically similar to that of the J57, described on the preceding page. Overall diameter, 58.5in; length, as depicted, 214in (basic length, 191in); dry weight, 5,300 lb; mass flow, about 260 lb/sec; pressure ratio, 12.5:1; maximum thrust, 17,200 lb. With afterburner this engine gives a reheat thrust of about 24,500 lb. The civil JT4A series have ratings from 15,500 to 16,800 lb.





A row of J57-P-12 afterburning engines in the Chance Vought factory at Dallas, Texas, awaiting installation in the F8U-1, fastest aeroplane in the U.S. Navy. One such engine recently operated at maximum-continuous rating for 3 hr 13 min while an F8U was setting up a new American coast-to-coast record.



One of the latest R.M.I. rocket motors for piloted aircraft is the LR8-RM-8, of which all but the turbopump is shown in the photograph on the right. Each of the four chambers is rated at 2,000 lb at sea-level.

duction facility in addition to being the centre of nuclear research.

Pratt and Whitney have been investigating the practicability of closed-cycle propulsion systems, of which the J91 was the first to reach the bench-testing stage. Such a unit probably operates at relatively low temperatures, and almost certainly employs gaseous media for heat-transfer purposes. The J91 is a large engine with a mass flow of some 400 lb/sec, yet, owing to the temperature limit of some 1,300 deg F in the final heat-exchanger, the thrust can scarcely be greater than 22,000 lb.

Late in 1954, when Pratt and Whitney were co-operating with the Oak Ridge national laboratory, the company ran an aircraft-type reactor for four days at 1,500 deg F using a closed circuit system filled with a liquid nuclear fuel—composed principally of UF_4—passed through nickel-alloy tubes by centrifugal pumps, the whole circuit glowing red-hot at well above industrial-reactor temperatures. Beryllium oxide was used as a reactor-core material and, since this does not absorb neutrons, the fuel entering the reactor at once became super-critical and only ceased to react as it flowed out at the other end. A molten-sodium circuit was used to cool the reflector, and power was controlled by a ram-positioned stainless-steel rod through the reactor centre. The reactor was of cylindrical form, 33.3in in diameter and 35.8in long, and it developed a peak power of 3,350 h.p., equivalent to just under 3,000 lb-thrust.

Pratt and Whitney are teamed with Lockheed Aircraft (Georgia Division) on the WS-125A programme, and Lockheed have themselves established a nuclear aircraft laboratory in the north Georgia mountains, jointly financed by themselves and the U.S.A.F. up to $12.6m. Lockheed recently published a diagram showing how nuclear turbojets might be installed in supersonic aircraft.

JT3. As the commercial variant of the J57 this engine has developed into a family of closely related units, all of which are essentially similar to the basic non-afterburning military engine. Thrust can be augmented by water injection to counter loss of power under tropical or high-altitude conditions. The Boeing 707 and Douglas DC-8 will each carry some 5,800 lb of water for use with the current JT3, which is the C-6 sub-type with a wet rating of 12,900 lb.

Much work still remains to be done in determining the optimum powerplant nacelle. Rohr will manufacture the complete pods and pylons, Douglas have developed a "blow-away" jet of bleed air which prevents foreign bodies from being sucked into the intake during ground running, and Boeing are flight-testing nozzles embodying noise-suppression and thrust reverse. The first JT3s are scheduled for delivery in three months' time for installation in PanAm's first 707 and when the engine enters scheduled service next year the basic powerplant will have logged over 4.5m hr.

JT4. First exhibited at the recent Paris Salon the commercial derivative of the J75 has a conservative rating and should have a long and trouble-free life. Equipment can include water injection, twin G.L.A. high-voltage ignition boxes, Holley fuel control and a saddle oil-tank of no less than 9 U.S. gal capacity. Current orders amount to more than 960 engines. The success of the JT4A stems principally from the fact that the basic J75 has always been a firm military project, with the assurance of substantial development and rapid build-up of flight time. The latter should reach 350,000 hr by the time JT4A scheduled service starts in 1959.

JT8. Under this designation Pratt and Whitney have developed a commercial variant of the J52 medium-thrust turbojet. Basically similar to the Navy engine but without an afterburner, the JT8 can be considered fairly highly developed. It has yet to be sold but should be suitable for such aircraft as the Boeing 727, Douglas 1925 and Bristol 200.

JT9. Such an engine is at present under development at East Hartford. It has been suggested that it may well be a turbofan or by-pass unit.

T34. Described in our 1956 review, the T34 is in small-scale production as the powerplant of the Douglas (Long Beach) C-133A heavy logistic transport of the U.S. Air Force. The engine has flown more than 30,000 hr in various aircraft operated by M.A.T.S. At present it has a 750-hr overhaul life and a 1,000-hr cycle is expected by the end of the current year.

T57. Also briefly described in our 1956 review, this 15,000/20,000 h.p. high-pressure turboprop reached the flight-test stage last year mounted in the nose of a Douglas C-124. Owing to the cancellation of its application—the giant C-132 transport—the engine is at present "on the shelf".

Piston Engines. The only engine in large-scale production is the R-2800 Double Wasp, an 18-cylinder radial rated at 2,000 to 2,500 h.p.; it is produced for the CV-440 and its military variants, the DC-6 family, the C-123 Provider, the Bréguet Deux Ponts and all Sikorsky S-56 helicopters.

R.M.I. *Reaction Motors, Inc., Denville, N.J.* As the company responsible for the original 6000C4 four-barrel rocket motor for the Bell XS-1 (which in 1947 was the first piloted aircraft to exceed the speed of sound) R.M.I. were the first firm outside Germany to develop advanced rocket-propulsion sytems for aircraft. The company handled the complete propulsion for the later Bell X-1 research aircraft, which were equipped with improved versions of the same motor; the 6000-series motor operated on liquid oxygen and ethyl alcohol and was described and illustrated in our 1956 review.

In 1955 R.M.I. joined with Marquardt (*q.v.*) and Olin Mathieson in the OMAR co-operative group. Initially established at Rockaway, N.J., a test facility was later built at Lake Denmark in the same State, and in October 1955 R.M.I.'s new headquarters was established at Denville, seven miles from Lake Denmark, operated jointly with the U.S. Navy. Research and engineering buildings at Denville total 200,000 sq ft and the site also houses a production plant and 20 test stands for liquid-propellant motors. In June last year the company commissioned a stand capable of testing motors of up to 1,000,000 lb-thrust in any attitude in pitch and roll.

Most of the company's experience with large motors was gained with 20,000 lb-thrust chambers for the Martin Viking high-altitude research vehicles. In the autumn of 1955 R.M.I. had made about 75 runs on 50,000 lb-thrust chambers, and had also fired a chamber rated at 120,000 lb. The majority of the firings had taken place on liquid oxygen and alcohol. As recently announced, R.M.I. are developing a very advanced design of motor for the North American X-15 hypersonic research aircraft. The company are unable to confirm a statement published in an American journal which described the unit as a self-contained motor, with a light weight and simple structural mountings, rated at 60,000 lb-thrust and with a firing-time of from one to three minutes. In the outer reaches of the atmosphere this motor would give far greater thrust than any other combination of powerplants yet fitted to any piloted aircraft.

In the field of helicopter tip-drive the company have conducted extensive investigation into small rockets fed with H.T.P. from tanks mounted either in the fuselage or above the rotor hub. The latter disposition is used in the Rocket-On-Rotor system which puts 120 extra h.p. into the rotor of the S-55. Diminutive 16-lb peroxide motors are fitted to the Rotor-craft RH-1 and Kellett KH-15 light helicopters; the latter aircraft may ultimately have a different type of tip drive.

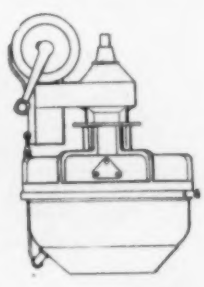
Among the company's other interests are the ICAC internal-combustion aircraft catapult, which is currently being evaluated by the U.S. Navy, as well as a variety of other launching devices and investigations into high-energy liquid and solid propellants. Employment exceeds 1,800 and government contracts in 1956 totalled $16.2m.

SOLAR. *Solar Aircraft Company, 2200 Pacific Highway, San Diego, California.* During the past year Solar announced the existence of their first small turboshaft engine intended primarily for aircraft propulsion (the Mercury, described below). Their other turbines comprise the Mars, Jupiter and Saturn, which are chiefly used in applications other than aircraft propulsion.

Rated at 50 h.p., the Mars has a centrifugal compressor and an inward-flow radial turbine mounted back-to-back and turning at 40,000 r.p.m. Driving airborne auxiliary powerplants, about a thousand Mars have been sold, with a total of over 500,000 hr of trouble-free service at a present U.S.A.F. overhaul life of 750 hr. The engine is used to provide accessory power in the C-124C, KC-97, C-121C and C-131B. The larger Jupiter is a 500 h.p. axial split-wheel design with a free power-turbine. An air-bleed configuration is in bulk production as a compressor pack for multi-purpose turbojet support vehicles; a constant-speed version is associated with electric generation and a variable-speed version is used for marine propulsion. The most powerful Solar engine is the 1,000 h.p. Saturn, which does not yet have aircraft-propulsion applications.

Solar is a pioneer in the afterburner field and is currently providing technical information under an agreement with Bristol Aero-Engines. Major parts are manufactured for the J57, J71 and J79 turbojets; considerable missile sub-contract work includes manufacture of bodies for Falcon and components for various other weapon systems.

In April the company's backlog exceeded $90m. Substantial extensions to the plant at San Diego and to the company's second facility at Des Moines, Iowa, brought total floor-space to 1,264,400 sq ft, and aggregate employment is approximately 6,500.



Solar YT62 Mercury. Turboshaft engine for the propulsion of (initially) a one-man helicopter. Centrifugal compressor, annular combustion chamber and single-stage turbine, probably of the inward-radial-flow variety. Overall diameter, 15½in; overall height as depicted, 20in; dry weight, 50 lb; maximum rating, 55 s.h.p. + 12 lb residual thrust at 57 600 r.p.m. All other data on this engine are restricted.

AERO ENGINES 1957 . . .

Mercury. As far as is known, the YT62 Mercury is the smallest gas-turbine aero-engine yet designed. The company have for some months been developing the engine under a joint contract from the Navy Bureau of Aeronautics and the U.S. Army, and the powerplant is being matched to a one-man helicopter. As the diagram (p. 139) shows, starting is by a hand-crank which is geared up to the compressor/turbine shaft. Air is taken in around an annulus above the compressor casing and passed through the centrifugal impeller and a cascade of radial/axial diffuser vanes before entering the annular combustion chamber. In the latter the gas flows forwards and inwards before passing through the turbine and leaving the engine through a centrally mounted exhaust pipe. Further information on the engine is restricted; as far as is known it has not yet run.

WESTINGHOUSE. *Westinghouse Electric Corpn., Aviation Gas Turbine Division, P.O. Box 288, Kansas City, Mo.* One of the giants of American industry, Westinghouse entered the aero-engine field under contract to the U.S. Navy in 1942. Without assistance, the company formed an Aircraft Gas Turbine Division which planned a range of axial turbojets of remarkably advanced conception. Except for a little Japanese work, these were the first axial engines to be designed outside Europe and they were also the first turbojets of wholly American design. Three sizes of closely related engines were developed, with diameters of 9.5in, 19in and 24in. The 19in engine went on to the bench in March 1943 and flew in January 1944. Later, as the J30, it was licence-built by Pratt and Whitney.

The 24in engine developed into the J34 described below, and is the only Westinghouse gas-turbine to have been really successful. In 1947 work began on a much larger Navy engine designated J40, rated at 7,500 lb dry-thrust, and this was developed for installation in advanced carrier-based fighters and bombers. Although it brought the Navy its first world speed record and also propelled a U.S.A.F. test vehicle to speeds never previously reached by a gas-turbine, the engine was never cleared for operational service and such major programmes as the F4D, A3D and F3H had to be re-engined.

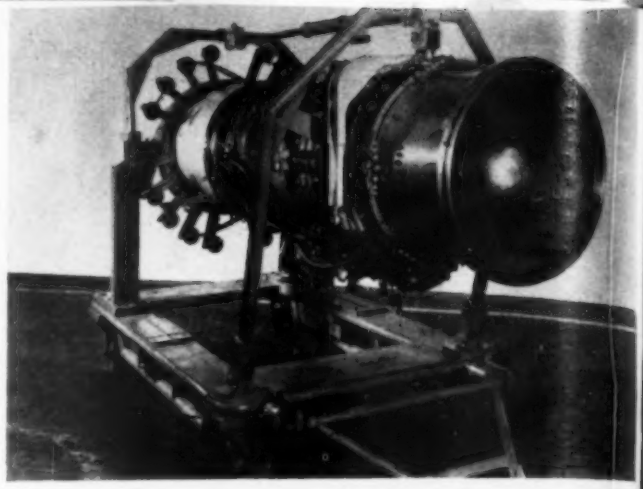
In our 1956 engine review we outlined the rationalization programme which the company have undertaken, the A.G.T. Division now being centred at Kansas City, with the flight-test establishment 20 miles south at the Naval Air Station at Olathe. Production during the past three years has centred on the J34 and the somewhat more advanced J46. In 1953 a technical agreement was signed with Rolls-Royce and there has since been considerable co-operation between the two companies especially in respect of the J54 and J81. The former, incidentally, is more of a private-enterprise venture than any other American turbojet.

At least $12m of company money has been spent on a new turbojet laboratory and test facilities at Kansas City, and the A.G.T. Division also works closely with the company's Central Research Laboratories in Philadelphia. Much fundamental research has been undertaken at Kansas City, particularly into gas-turbine materials. In May the company revealed that they were in receipt of a Navy contract "to test, evaluate and select laminated-plastic material to be used in the fabrication of J34-WE-36 jet engine compressor housings." Having tested a J34 with a compressor casing of commercially available plastics, Westinghouse are confident that newer plastics can result in casings costing about one-third as much as finished magnesium casings while losing nothing in the matter of weight or durability. Another recent investigation has concerned hollow turbine nozzles stretch-formed from molybdenum-alloy sheets clad on both sides with Inconel and wrapped to an aerofoil profile and brazed at the trailing edge. Such vanes have been cycled over 25 hr in a J46-WE-18 at a metal temperature of 2,070 deg F, with promising results.

J34. Several thousand of these neat single-shaft engines have been built since 1946 and small orders are still coming in. One of the first aircraft to use the engine was the McDonnell F2H Banshee, of which over 800 were built. The engine also powers the Douglas F3D which, like the F2H, saw operational service in Korea. The most recent production-application concerns the latest versions of the Lockheed P2V Neptune in which the J34 is used as a booster mounted in underwing nacelles. Total flight time is now 1¼m hr.

Production ceased in 1955 and the first P2V nacelle contracts were filled from existing stocks. Manufacture of new J34s began again early last year, and an advanced version, the J34-WE-46, has been selected as the powerplant of the North American 246 (T2J) Navy trainer. The engine has also been selected for wing-tip boost employment on the Lockheed W2V radar picket, although this project is now in abeyance. The J34 was described in our 1956 aero-engine review.

J46. Some hundreds of afterburning variants of this engine are in service as the powerplant of the transonic Chance Vought F7U Cutlass missile and reconnaissance fighter of the U.S. Navy. Various types of J46 have also been used in later versions of the Convair Sea Dart. A particularly noteworthy feature is the iris-type variable-area afterburner propelling nozzle, which is automatically adjusted to give correct engine operation. The engine was described in our 1956 review.



Chief engine-development programme by Westinghouse concerns the J54 turbojet. This specimen is fully calibrated for running in a test-cell. Special instrumentation is provided for measuring airflow.

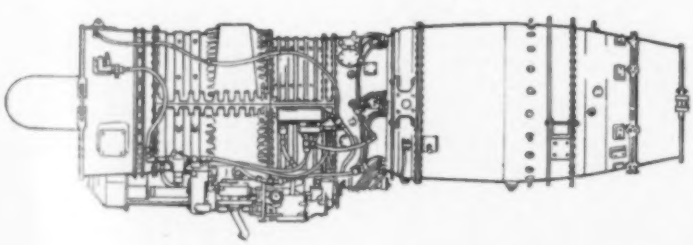
J54. Westinghouse have staked a great deal, including $13m of their own money, in this three-bearing single-shaft turbojet. Its design has been undertaken with assistance from Rolls-Royce engineers, and the compressor is aerodynamically related to that used in the 200-series Avon. Its vaporizing combustion system is based on the work of Armstrong Siddeley. The J54 is an engine of high quality and Westinghouse have spared no effort to ensure the retention of all the advantages of simplicity, efficiency and low weight and cost.

While the design was in progress, the company conducted an evaluation into the optimum material for each part. Although magnesium alloy, stainless steel and other traditional materials have by no means been excluded, titanium has been employed on a scale which, compared with previous gas-turbines, is exceedingly widespread. The company recently stated "co-operative development programs with various titanium suppliers are aimed at providing large titanium forgings, compressor discs and shafts which can satisfy the same thermal-stability requirements presently being met by compressor blades forged from titanium-alloy bar-stock. Advances in the state of the art gradually are overcoming the limitations to the use of titanium alloys at higher stress levels and higher temperatures. Weight reductions and design advancements, prompted by materials research, can be forecast for improved J54 designs already in development. Such improvements will result from development of new alloys with higher strength-to-density ratios, wider use of heat-treated titanium alloys, and greater understanding of factors leading to thermal instability."

With the assistance of the new Westinghouse gas-turbine research facilities, and of the engineers from Derby, the J54 was brought on to the bench only 11½ months from the start of design. Performance specifications were met on the first run, and in subsequent testing at Kansas City development has been completed which should ensure performance improvements in forthcoming configurations of the engine. High-altitude trials were undertaken at the Naval Air Turbine Test Center at Trenton, N.J., and flight trials have been undertaken with a unit mounted under the bomb-bay of a B-45. Westinghouse state that the J54 has successfully completed all the required tests through a range of conditions limited only by the performance of the test-bed aircraft. The combination of variable inlet guide vanes and compressor bleed from a large casing near the middle of the spool have sufficed to provide completely stall-free operation, and slam accelerations have been accomplished at altitudes more than 20-per-cent higher than the B-45's normal (i.e. without J54) service ceiling.

The basic J54-WE-2 has successfully run a 150-hr endurance test, and component development for improved versions has been completed These later units may find important applications in military and/or commercial fields. At the moment, however, the future of the engine is uncertain and the extent of further testing will depend on military sponsorship.

J81. In its essentials the J81 is the Rolls-Royce R.B. 82 Soar, a small highly rated axial engine of monocoque construction and with a thrust/weight ratio (6.78) which was unprecedented when the engine was publicly revealed in 1953. A batch of Soars was supplied to Kansas City from Derby and these were Americanized and used as a basis for development. The present J81 is in no sense a Chinese copy of the British unit and represents considerable Westinghouse effort. Its chief application is the propulsion of the radioplane XQ-4 supersonic drone, which is now being evaluated at Holloman A.F.B.



Westinghouse T54-WE-2. Single-shaft turbojet. Sixteen-stage compressor, annular combustion chamber with 24 burners and two-stage turbine. Overall diameter, 35in; length, 158in as depicted, 120in basic; dry weight, approximately 1,400 lb; mass flow, 100 lb/sec; pressure ratio, about 8:1; maximum thrust, 6,500 lb with s.f.c. of 0.85. Later variants of this engine are scheduled.

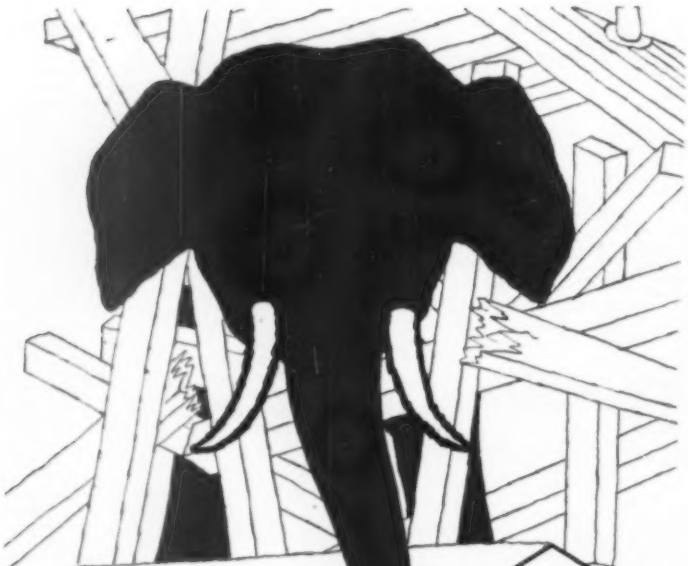
THE BRAZILIAN NAVY *selects the* WIDGEON

After evaluation of the qualities and capabilities of available helicopters of comparable type, the Government of Brazil has determined that the Westland Widgeon meets all the requirements specified for operational service with the Brazilian Navy.

WESTLAND

The Hallmark of British Helicopters

WESTLAND AIRCRAFT LIMITED · YEOVIL · SOMERSET



. . . but specify
Bostik *for*
constructional work
that withstands
all strains

When it comes to permanent and dependable sealing you can rely upon 'Bostik' Sealing Compound.
Produced to withstand all flight strains, 'Bostik' has proved itself the top-flight sealing compound during more than twenty years of flying.
Tell you more about 'Bostik' for pressurized cabins, integral fuel tank sealing, screen glazing?
We'll be glad to.

The word 'Bostik' is a registered trademark of:—

B. B. CHEMICAL CO. LTD., ULVERSCROFT ROAD, LEICESTER

HONG KONG AIRCRAFT ENGINEERING COMPANY, LIMITED

numbers among its customers:

Aigle Azur Extreme Orient
Air India International
Air Vietnam
Bataafsche Petroleum Maatschappij
Brunei Shell Petroleum Co., Ltd.
Canadian Pacific Airlines
Civil Air Transport
Garuda Indonesian Airways, N.V.
Korean National Airlines
Malayan Airways Limited
Nederlandsche Nieuw Guinea Petroleum Maatschappij
Philippine Air Lines, Inc.
Royal Air Cambodge
Standard-Vacuum Petroleum Maatschappij
Swissair
Thai Airways Company, Ltd.
Air France
Air Laos
Bahamas Helicopters, Ltd.
British Overseas Airways Corporation
Caltex Pacific Petroleum Maatschappij
Cathay Pacific Airways
Federation Air Services
Hong Kong Airways
Macau Airtransport Co. (HK), Ltd.
Mandated Airlines Limited
Northwest Orient Airlines
Qantas Empire Airways
Scandinavian Airlines System
Tasman Empire Airways, Ltd.
Union of Burma Airways Board
World Wide Air Services

Also

Burma Air Force
Royal Air Force
Royal New Zealand Air Force
United States Air Force
United States Navy
French Air Force
Royal Naval Air Services
Royal Thai Air Force
United States Marine Corps.
Vietnam Air Force

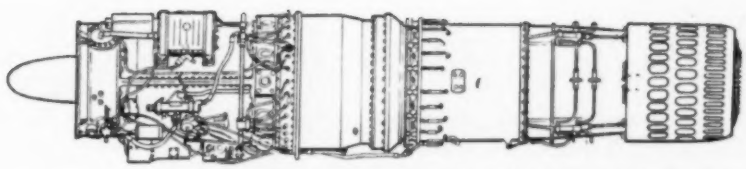
Inquiries for

Airframe, engine, instrument, accessory overhauls, repairs, modifications

to

HONG KONG AIRCRAFT ENGINEERING COMPANY, LIMITED
KAI TAK AIRPORT, HONG KONG **Cable Address: AIRENG**

AERO ENGINES 1957 . . .



Wright J65-W-6. Single-shaft turbojet with afterburner. Thirteen-stage compressor, annular combustion chamber with 36 vaporizing burners and two-stage turbine. Diameter, 37.9in; length, 195in; dry weight, 2,780 lb; mass flow, 120 lb/sec; pressure ratio, 7:1; maximum thrust, 11,200 lb with reheat, at 8,200 r.p.m., with s.f.c. of 1.97. The basic engine has a dry rating of 7,800 lb thrust with s.f.c. of 0.91.

WRIGHT. *The Wright Aeronautical Division of the Curtiss-Wright Corpn., Wood-Ridge, N.J.* For many years Wright have been world leaders in aircraft propulsion, yet their performance in the gas-turbine era has been disappointing. Undoubtedly the Turbo-Compound is an outstanding powerplant, in spite of a relatively high incidence of mechanical trouble, and Wright have also done a fine job in developing and mass-producing the J65 Sapphire to a basic British design; yet no engine of Wright design has achieved success since the R-3350 of almost twenty years ago.

The company's first gas-turbine was the big T35 Typhoon turboprop which got as far as the flying stage. In 1950 the company obtained a profusion of licences in respect of British gas-turbines designed by Armstrong Siddeley and Bristol, and the Sapphire and Olympus were each chosen to form the basis of an American turbojet, as described below. Attempts to convert these engines into ambitious turboprops were unsuccessful, and even the development of the basic J67 has proved to be long and protracted. Only now is it likely to achieve success as part of an exceedingly interesting dual-cycle powerplant which, if financial considerations do not first cause its cancellation, may lead to an attractive system of propulsion for high-supersonic aircraft. Efforts are now being made to enter the commercial field with the TJ-38 turbojet. All responsibility for piston engines other than the Turbo-Compound is vested in Lycoming (*q.v.*).

At present Wright Aeronautical Division is concentrating on large engines, and units up to 7,500 lb-thrust and comparable turboprops are the responsibility of the Turbomotor Division, which was organized in January 1956 with headquarters at Hempstead, N.J. Headquarters of W.A.D. is still at Wood-Ridge although it is scheduled to be relocated in the neighbourhood of Suffern, N.J.; the main research and development establishment is being steadily built up on a vast 85-sq-mile site named Quehanna in central Pennsylvania, and a further extensive estate west of the Rockies has been allocated to future rocket and ramjet development.

Other products of the corporation include Turbolectric propellers, simulators and related equipment by the Electronics Division; a variety of engine and airframe detail parts by the Marquette Metal Products Division; the Aerophysics Development Corporation, who have designed hypersonic test vehicles and the Dart anti-tank weapon system; the Utica-Bend Corporation who mass-produce the Dart missile and hold a U.S. Army study-contract for a 250 e.h.p. turboshaft engine (independent of one held by the Turbomotor Division); a Metals Processing Division; and Caldwell-Wright Airport, Inc., who *inter alia* maintain the corporation's experimental aircraft. Curtiss-Wright Europe, N.V., is a wholly owned subsidiary in the Netherlands principally concerned with service-support of U.S.A.F. and NATO J65s.

Recent developments by the Propeller Division include: a very neat thrust-reverser for turbojets "from 2,000 to 25,000 lb-thrust" which has been fully developed during four years of rig running; an all-mechanical engine speed control for helicopters, offering unique advantages; and a variable-exhaust-nozzle control system for advanced turbojets giving infinite variation over a wide range of conditions.

In August last year Curtiss-Wright undertook a three-year advisory management agreement to assist Studebaker-Packard, and took a twelve-year lease on two S-P plants. Aerophysics Development and Utica-Bend, both previously mentioned, were purchased from S-P to implement Wright's missile programmes. Utica-Bend is also overhauling J47 turbojets and making J57 parts for Ford.

Earlier this year Curtiss-Wright and Studebaker-Packard jointly associated themselves with the great German firm of Daimler-Benz, and all three organizations are to co-operate in research, production and sales on a world-wide scale. Total Curtiss-Wright backlog at the beginning of the year was over $746m, and the number of employees 32,237, an increase of over 4,300 compared with 1955.

J65. In 1950 Wright recognized that the basic design of the British Sapphire turbojet was sufficiently outstanding for it to command acceptance in the American market. After purchasing a licence, the engine was converted to U.S. standards and flown beneath a B-17, and in 1951 it was bought by the U.S. Air Force as the powerplant of the Republic F-84F and Martin B-57 (Canberra).

Since that time a variety of J65s have become widely used by the U.S. Air Force and have flown at high supersonic speeds in F-104 prototypes. Over 1,000 J65s have also been delivered to the Navy for use in the FJ-3 and -4 Fury, F11F Tiger and Regulus II. Compared with the British Sapphire 100, the J65 incorporates complete detail redesign; the example illustrated is a typical fighter engine for the F11F-1 Tiger, with a steel ribless compressor casing and a short afterburner. Second-source production was undertaken by Buick between 1952 and early 1956, and approximately 10,300 J65s have now been manufactured. The rate of production has already appreciably slowed and next year deliveries will be required only for the Fury FJ-4B.

Naturally Wright wished to extract from the J65 the maximum amount of business, both in the military and commercial fields. Considerable behind-the-scenes activity has followed two main paths. One branch has aimed at the establishment in America of an advanced military Sapphire (200-series derivation). Cool, long-life engines would have been offered to the U.S.A.F. for re-engining B-47s, a proposal which was at one time very seriously considered and would have meant a requirement for some 20,000 engines. At the same time a hot, afterburning fighter engine would have been offered to the Navy, particularly for advanced versions of the Tiger. The other branch of investigation concerned an engine designated TJ-31F, a cool commercial turbojet which, it was hoped, would be sold to transport manufacturers. Unfortunately neither scheme has come to fruition, largely as a result of factors unconnected with the engines themselves.

J67. When Wright bought the Olympus licence in 1950 they decided that, as the engine needed substantial development in any case, they would themselves work on it to produce a wholly American engine of increased thrust. A U.S.A.F. development contract was awarded for an engine designated J67. By way of the intermediate TJ-32B, this engine is now nearing the definitive stage. Early on, however, the U.S.A.F. saw that Wright could not develop a usable engine as fast as Pratt and Whitney (or Bristol) and no production of the J67 was ordered. It does, however, find a niche in the company's dual-cycle work, referred to overleaf.

J47. A particularly ambitious proposal of the Wright Aeronautical Division was the evolution, from the Olympus/J67 series, of a turboprop of some 15,000 h.p. As far as is known, the project is dead.

T49. Unlike the preceding engine, this turboprop version of the J65 Sapphire not only reached the hardware stage but also accomplished a fair amount of flying in a pair of XB-47Ds. The big single-shaft turboprops replaced the inboard twin-J47 nacelles, and drove large ducted-spinner propellers. The XB-47D did not inspire confidence among those who flew it, and virtually all development has now ceased. One of the original aims of the programme had been to produce a de-rated constant-power engine for commercial use.

TJ-38 (company designation). Announcement of this very attractive commercial turbojet was made in May of this year. After considerable market-study it was decided to offer to the airlines a cool-running version of the second-generation Olympus—i.e., a derivative of the Olympus 510 series in replacement of a previous Wright proposal for the series-550 engine. Actual detailed engineering of the TJ-38 was conducted by Bristol, and the British firm have a fairly close counterpart in the Zephyr (*q.v.*).

Wright/Bristol TJ-38 Zephyr. Two-spool commercial turbojet. Five-stage low-pressure compressor, seven-stage high-pressure compressor, can-annular combustion chamber with eight flame tubes, single-stage high-pressure turbine and single-stage low-pressure turbine. Overall diameter, 41in; length from intake to exhaust flange, 121in; dry weight, equipped, 3,600 lb; mass flow, not stated; pressure ratio, 10.5:1; maximum thrust, 12,500 lb with turbine-entry temperature of 1,000 deg K and s.f.c. of 0.718; cruise rating at Mach 0.8 at 36,089ft, 3,000 lb thrust with s.f.c. of 0.88. In appearance the Zephyr will closely resemble the Olympus 6 (p. 114).

Turbine-inlet temperature in the TJ-38 is only 1,340 deg F, and several major advantages accrue as a direct consequence: the rated dry thrust of 12,500 lb can be held in adverse temperature or altitude conditions; water injection is not required; noise level is exceedingly low (and is further reduced by a segmented propelling nozzle); and reliability and service-life should be exceptional. Wright have pointed out that the basic Olympus design is backed up by over 30,000 hr of full-scale running, and that it should soon be possible to achieve full certification and work up to a very long overhaul period. As the accompanying data reveal, the specific consumption and weight are also exceedingly attractive. Roy T. Hurley, Curtiss-Wright chairman and president,

During 1956 the two XB-47D test-bed aircraft flew many hours with the Wright T49 turboprop. Here one is seen from a KC-97 tanker.

AERO ENGINES 1957 . . .

recently stated that Bristol-built TJ-38s would be available to airframe manufacturers next summer, and that American-fabricated models would be delivered from Wood-Ridge early the following year.

WTF-80. Under this designation Wright have for a considerable period been developing a turbofan (by-pass engine) which was reported to have been "authorized last year when Wright were helping Studebaker-Packard." The same report averred that $2.2m were allocated from the Pentagon emergency research and development fund. Yet another by-pass project is reported to be the WTF-10.

Dual-cycle. Under the management of Harry N. Price, a Curtiss-Wright chief project engineer, this propulsion system is now reaching an advanced stage of development. Essentially it comprises a supersonic intake feeding to a bifurcation provided with a large flap-valve shutter which can pass the air either to a J67 turbojet or to a large ramjet, the latter being brought into circuit at high supersonic speed. The only announced application of a dual-cycle powerplant of this type concerns the Republic XF-103 experimental research aircraft, intended originally as the forerunner of a piloted fighter capable of about Mach 3.5. The programme is proceeding at a fairly low priority, and, although "strong commitments" have been made to the project by the U.S. Air Force, very little financial allocation is being awarded in the current financial year.

Turbo-Compound. This 18-cylinder engine remains in full production on a largely automatic assembly line at Wood-Ridge, and is being delivered in large quantities for military and commercial applications. Highest overhaul time in American domestic operations is the DA-3 version operated by Northwest Airlines on a 1,300-hr cycle. The same airline will this September be the first to receive DC-7Cs with EA-4 engines, cruising at 1,975 b.h.p. in low-blower or 1,950 in high-blower. A similar engine is the EA-5 of the Lockheed 1649A. The earlier EA-1 and -2 used in current DC-7Cs and L.1649As is rated at 3,400 h.p. for take-off and has a m.e.t.o. rating of 2,800 h.p. For the record, the (non-Compound) Cyclone R-3330 BD-series has now reached the record overhaul time of 2,025 hr, with Eastern Airlines.

Ramjets. In July 1955 a $7.7m laboratory was opened at Wood-Ridge for the altitude testing of large supersonic ramjets. For several years the company have been developing an exceedingly impressive 48in engine designated RJ47, which is used as the powerplant of the North American Navaho cruise-type missile (recently cancelled). As far as is known the RJ47 is the most powerful air-breathing engine yet made.

Rocket motors. Chief among several designs of Wright rocket motor is the LR25, powerplant of the Bell X-2. This aircraft has flown faster than 2,000 m.p.h. and higher than 126,000ft. Rated at a total thrust of 15,000 lb in its latest version, it operates on liquid oxygen and alcohol, fed by a turbopump. Single-lever control of thrust is provided.

U.S.S.R.

UNTIL the end of World War 2 the Soviet Union was technologically unable to design competitive aero-engines, except those of the smallest and simplest character. All other units were modelled upon proven designs from other countries, and in particular engines designed by Hispano-Suiza, Pratt and Whitney and Wright were "Russianized" and manufactured in great numbers. By 1945 the Russian was competent to stand on his own feet in the realm of piston engines, but it was then already apparent that the dominant military powerplant would be the gas turbine and in this field work had to begin again from scratch.

During the past decade the Soviet Union has made extraordinary progress in the development of indigenous gas-turbine aero-engines, and today has in wide service several ambitious powerplants for which the West can find no parallels in a comparable time-scale. To a considerable extent this remarkable advance has been facilitated by assistance from Britain (voluntarily) and from German engineers (involuntarily), but for several years Soviet designers have been producing a complete range of advanced powerplants without outside assistance, and there is no doubt that they will continue to do so. Work is going ahead on a broad front, but it is only in the reciprocating and turbine fields that any firm information is available.

Turbojets. Thirteen years ago Russia had neither native turbojets nor engineers capable of undertaking the design of any. But by the spring of 1945 examples of the B.M.W.003 and Jumo 004, both turbojets widely used by the Luftwaffe, were shipped to Russia for examination, and several German gas-turbine production plants fell into the hands of the Red Army. Later in the same year Russia had the Junkers engine in limited production, but the B.M.W. unit was ultimately considered more attractive and a Russian development, the RD-10 (described in our 1956 Aero Engines issue) was built in large numbers and used in the first generation of Soviet jet fighters. These early axials have since exerted considerable influence on later Russian jet families, although current units are appreciably more advanced in concept.

In 1947 an event occurred which was of enormous immediate value in assisting the Russians to establish their own gas-turbine industry. This was the supply by the British Government of a quantity of Rolls-Royce centrifugal turbojets (25 Nenes and 30 Derwents), together with manufacturing drawings and assistance in providing instruction and tooling for the production of these engines. Neither Russia nor the German engineers had any experience with an engine in the same class as the Nene. The 5,000 lb-thrust of this engine and the advanced engineering and long life of its components was a revelation which opened the way to a wholly new treatment of the problem. Within a matter of days it was decided to manufacture both the British engines in Russia, and preparations to do so were put in hand with a high priority. Production of the Derwent, direct from British drawings, was put in hand forthwith. Some hundreds are believed to have been produced, chiefly for the Yak-23; the engine is designated RD-500.

A large team of engineers, headed by Chelomey and Klimov, was assigned to the vast task of converting the basic Nene engine to Russian standards and analysing the new alloys involved and determining the manufacturing problems, setting up sources of the multitude of completely new detail parts and accessories required and tooling up a large plant for the assembly, inspection and testing of the final units. Early in 1949 the RD-45, as the engine was known, was in full production at Engine Plant No. 45, near Moscow. Meanwhile, work was put in hand by an all-Russian staff in order to improve the design of the engine and increase its thrust. The Mig-15 fighter and Il-28 bomber were both designed to use the engine, and both aircraft flew in 1950. Shortly thereafter Vladimir Klimov produced an improved engine designated VK-1, incorporating numerous improvements in design and materials. One cannot over-emphasize the value to Russia of the British centrifugal engines in that they were ideal instruments with which Soviet engineers could learn the problems inherent in manufacturing and developing the aircraft gas-turbine.

Between 1950 and 1956 more than 20,000 VK-1 engines are reported to have been manufactured. The majority have been fitted to the Mig-15 and Mig-17 (10,000 Mig-15s were built during the period of the Korean War), but probably more than 5,000 VK-1s must have been required to meet the needs of the Il-28 programme. As far as is known, Plant 45, under its manager Kuindzki, has undertaken all the bulk production of the engine. Although not a new factory, it is well equipped with machine tools from many countries; a curious fact, but one which is often found in Russia, is that part of the plant is devoted to a quite different product, in this case farm machinery. Last year the work-force in the assembly of the VK-1 was approximately 3,000, and at the end of 1956 production was switched over entirely to a modern Soviet axial turbojet.

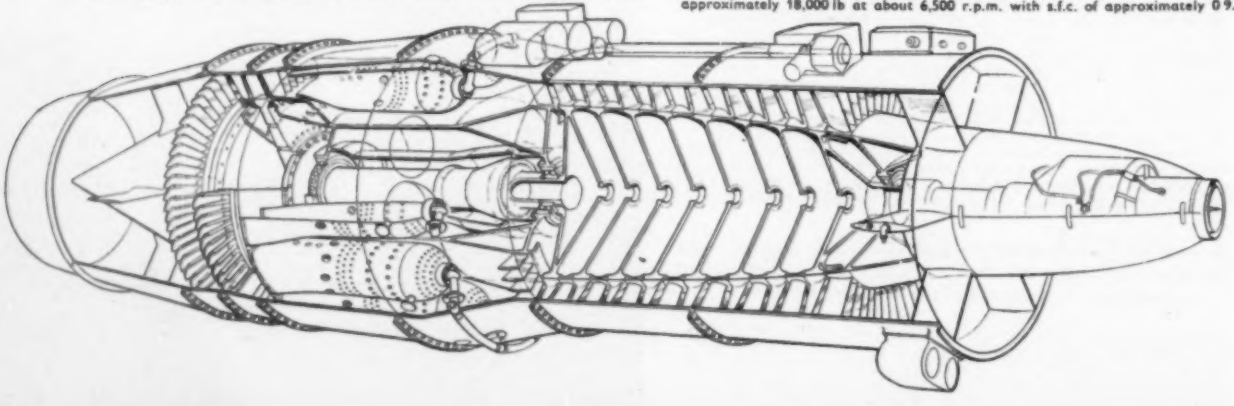
Russia extracted all she could from the basic Nene concept and in this regard probably surpassed the efforts of Britain, France or the U.S.A. From the outset, however, long-term plans were laid for the development of advanced axial engines, and large numbers of German engineers, particularly those from Junkers and B.M.W., were deported to the Soviet Union at the end of World War 2 to provide technical assistance.

Initially, while production of the simple RD-10 got under way, the Germans were told to carry on with the development of the Junkers 10[illegible].012 turbojet, which in 1945 had been a major project at the Otto Mader establishment. The 012 had been intended to meet Luftwaffe requirements for an engine of 3,000 kg (6,615 lb) thrust with a specific consumption fractionally over 1—i.e., an all-round performance marginally better than the Nene. Starting in the winter of 1946-47, the ex-Junkers engineers designed an engine similar to the 012 virtually from scratch—the original drawings having been lost—and had a prototype running on the bench in little more than a year. The engine was used in several Russian aircraft but was not placed in bulk production.

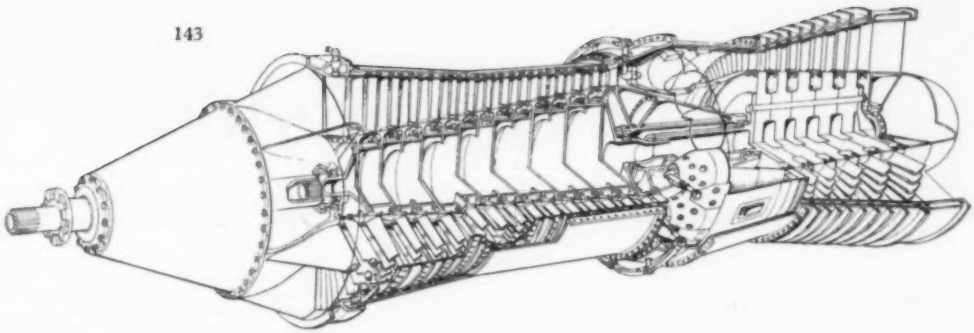
By 1951 Russia's own turbine engineers had been formed into design teams of no mean calibre, and with their considerable research equipment and experience of British centrifugal and German axial engines were ready to start major programmes of their own. One of the first and biggest assignments was the design of an axial turbojet larger than any engine previously made (excepting the J53). The first of this family of engines, which have been ascribed to the designer Mikulin as the M-209, must have been running before the end of 1952.

An accompanying cut-away drawing indicates major features of this relatively simple engine. It employs a moderate pressure ratio and has design points which are not particularly ambitious; and it may well be an outcome of the conservative rating of the engine that it has now probably logged a seven-figure flight-time and has proved itself eminently reliable.

Initial development of this series of powerplants was directed towards



Mikulin M-289 (provisional designation). Single-shaft turbojet. The configuration of this engine can be deduced from this *Flight* copyright drawing. Overall diameter, estimated at 54in; length, estimated at 200in; dry weight, estimated at 5,500 lb. mass flow, approximately 278 lb/sec; pressure ratio, 6.8:1; maximum thrust, approximately 18,000 lb at about 6,500 r.p.m. with s.f.c. of approximately 0.9.



Type K Turboprop. Single-shaft turboprop. The configuration of this engine can be deduced from this *Flight* copyright drawing. Overall diameter, 45.3in; overall length, 236.2in; dry weight, 5,070 lb; mass flow, at cruising r.p.m. of 8,250, 137 lb/sec; pressure ratio, 9.5:1 at sea level rising to a peak of 13:1 at 36,000ft; maximum rating, 12,000 s.h.p. + 2,645 lb thrust at 9,250 r.p.m. at sea level, with 930 deg K top temperature and s.f.c. of 0.573 (implying polytropic efficiencies over 90 per cent); maximum power at 36,000ft, 8,000 s.h.p. at 9,250 r.p.m. with top temperature of 1,150 deg K and s.f.c. of 0.353 lb/hr/s.h.p.

the evolution of a military engine for use in medium and heavy bombers, of which the most important designs were those known in the West as Badger and Bison. The former, a large Tupolev twin-engined medium bomber, was probably the aircraft which conducted most of the basic flight development of the M-209 in 1953-54, and in the latter year this aircraft was entering operational service with engines rated at about 18,000 lb dry. Probably a more important aeroplane is the four-engined Bison, and to meet the performance specified for this 352,000-lb bomber an up-rated version of the engine had to be developed (probably with a zero-stage on the compressor). Many hundreds of advanced M-209 units are now in service with this aircraft at ratings of the order of 20,500 lb. No other engine of comparable thrust is yet in service anywhere in the world.

Best known of the aircraft powered by the big Mikulin engine is the Tu-104, a simple and reliable twin-engined transport which first flew in June 1955. By the beginning of this year Tu-104s had probably flown several thousand hours and it is today the only jet airliner in scheduled service anywhere in the world. The powerplants are special transport versions of the M-209, fitted with electric starters, manifolds for cabin pressurization and hot-air de-icing. Water injection is not normally employed, and on its visits to the West the engine has used airline-type kerosine and synthetic turbo-oil. An accompanying drawing depicts a unit which is probably typical of the Tu-104-series powerplant.

As the illustration shows, the engine could hardly be more straightforward. The compressor has eight stages, each comprising a centreless flanged disc, with inserted blades housed in a parallel-sided casing split along the horizontal centre-line. The compressor is driven by a two-stage turbine with the second disc cantilevered by a ring of bolts from the disc of the first stage. Very good life is reported to be achieved by the can-annular combustion chamber, which is exceptionally large and appreciably increases the maximum diameter of the engine.

It is probable that there are today several hundred Badgers and possibly 200 or more Bisons in service, and many months ago a Russian described production of the latter aircraft by saying that they were "pouring out of our ears." It follows that the 209 must be logging many thousands of hours a week and that Russia must be building up an enviable record with so large and powerful an engine.

With the family of large axials well ahead in development, it was possible to turn to a smaller unit in which the natural effect of the square/cube law was coupled with the advantages accruing from fundamentally later design to achieve an outstanding medium-thrust turbojet with very small installational bulk and an exceedingly competitive thrust/weight ratio.

At the time of writing the designation and detail engineering of this engine are not publicly known in the West, but it is clear that no engine outside Russia in a comparable state of development can match it. Design points probably include a mass flow of about 115 lb/sec, a pressure ratio of about 8 : 1, and a top temperature of about 1,170 deg K. In its first generation, therefore, the engine must give a thrust of some 8,000 lb. It would be logical to have retained all the advantages of a simple single-spool configuration and a three-bearing layout, while stressing the engine for operation at high supersonic speed and making every effort to achieve long life and high reliability.

From the outset this engine has been of outstanding importance to Russian military planning, and some of the principal Russian military aircraft of the current generation were designed around it—with, so far as is known, no possibility of an alternate powerplant. The engine probably flew in the first half of 1954 and by the end of that year was certainly installed in the first Mig-19s and Yak-25s. As these are the standard day and all-weather fighters of the Russian Air Force, their production has probably already absorbed more than 5,000 of the new engines.

It is significant that in the examples so far seen the engines fitted to these aircraft are not fitted with an afterburner. Such an adjunct may be expected in engines now coming into service. Afterburners are certainly fitted to the big turbojets of the supersonic research aircraft seen at Tushino last year.

Turboprops. As the foregoing indicates, Russia's current turbojets are almost entirely indigenous in conception and development, but her shaft-turbines have in the past been based on pioneer work by German engineers deported to the Soviet Union after World War 2. These men, who totalled about 800, exclusive of their families, settled at Kubishev and were gradually moulded into a coherent series of research, design and development teams. In 1948, after they had worked on the early turbojets previously described, they were assigned the task of developing a turboprop in the 6,000-h.p. class.

No engine of this shaft-power had then been built, and the staff at Kubishev were faced with not only designing and directing the manufacture of the engine itself, but also of planning all the appurtenances that make up a complete powerplant as well as the many items of test and experimental equipment needed to bring the engine to the operational stage. Designated Type 022, the engine was based on a Junkers configuration of 1944, the engine having a single shaft and a simple axial compressor. The control system is unusual in that fuel-flow is a function of mass flow, top temperature presumably being held constant; r.p.m. vary with power output under the control of the propeller pitch lever, the latter being positioned according to the power setting.

The prototype 022 ran on the bench in 1950 and has since been widely used in several types of aircraft. Flight test was probably conducted with units mounted on Tu-4 (B-29) test-beds, and the engine was well developed when, in 1953, it was chosen to power the Antonov An-4/An-8 twin-engined, multi-purpose transport, which is now coming into service in both military and civil fields. In recent months the same engine package, with an identical propeller and cowling, has been fitted to the four-engined An-10, and it is likely that a related engine is the powerplant of the naval strike aircraft exhibited at Kubinka twelve months ago. In its production form the 022 has a diameter of 41.3in, an overall length of 177.2in, and a dry weight of 3,087 lb, including accessories; the maximum sea-level rating is 5,700 s.h.p. plus approximately 1,323 lb-thrust at 7,650 r.p.m., with an s.f.c. of 0.54.

In September 1950, when the basic design of the 022 was completed, a number of Germans were released from Soviet service. A relatively small group, however, consisting of some 100 engineers chiefly of Junkers origin, were retained to fulfil the awesome assignment of the development of a gas-turbine powerplant of 12,000 h.p., with an exceedingly low specific consumption. General Tupolev, dean of Soviet aircraft designers, had by then become firmly convinced that not only was the turboprop sufficiently economical on a miles-per-gallon basis for contemporary turbojets to be incapable of achieving anything like comparable range, but such engines could also be used to power a heavy bomber with a performance in no way inferior to that of jet bombers built to a similar time scale. He had already started the project design of a four-engined propeller-driven bomber with high-subsonic performance, and 12,000 was the minimum shaft horse-power necessary from each engine.

As a first attempt the Kubishev team were authorized to couple a pair of 022 engines to a common gearbox, in a manner similar to that of the British Coupled Proteus, with which the Russians were familiar. Such a scheme was unsuccessful, and it was soon clear that a completely new engine was required. The remarkably ambitious nature of the resulting unit is sufficient even today to command considerable respect, particularly when it is appreciated that the hundred engineers were given but three months to complete the whole basic design up to the issue of parts-drawings. Moreover, they were crippled by severe logistic problems in the areas of materials and machine tools, and also by the lack of research facilities or staff competent to tackle an engine conceived on such a scale.

In the design of the engine—which is known in the West only as the Type K—the German engineers ploughed a direct course and adopted logical palliatives to cure its resulting shortcomings. For example, a single compressor spool was chosen in order to obtain a pressure ratio of from 9 : 1 to 13 : 1 according to altitude, and a variety of blow-off valves and variable inlet guide vanes were added to improve basic handling. One must, however, interject at this point that the entire rotative assembly, weighing about a ton, is all mechanically connected together and, *via* the large reduction gear, to the propeller. The blow-off valves already mentioned were also found valuable in reducing the effort required to get the engine turning, and the production engine is started by a small gas-turbine rated at 65 h.p. driving through two-stage gearing with ratios of 1 : 18 : 24.

As the drawing shows, the compressor comprises flanged discs and spacer rings built up to form a single spool of fourteen stages. The casing is divided into four portions and is fabricated from steel sheet stiffened with U or T rings, the whole assembly being precision-welded with extreme care to retain dimensional accuracy—in itself no mean accomplishment. Combustion-chamber design initially follows a can-annular pattern, each flame-tube being centrally mounted on a downstream injector. At maximum flame-tube diameter, however, the cans merge together to form a truly annular secondary region, composed of inner and outer liners provided with axial intakes for dilution air. In a recent paper read by Dipl.Ing. Brandner, one of the engineers who worked on the Type K, the overhaul life of the combustion chamber is given as between 300 and 500 hours, and the recorded efficiency as over 98 per cent.

As the powerplant of the Bear this engine must now have flown something over 100,000 hours. It has been stated that commercial versions are being developed for a number of new transport aircraft, and these may be expected to be forthcoming next year.

Other Work. As in previous years, there is virtually no reliable information on Russia's progress in the fields of ramjets, rocket motors or nuclear power. Almost all that can be reported is that several suggested schemes for nuclear-powered aircraft have been published in Russian journals, and that a radio announcement has quoted the thrust of a large rocket motor—presumably for a ballistic missile—as 120 metric tons, or 265,000 lb.

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

Why Jackaroo?

READING C. M. Lambert's interesting article on flying the Thruxton Jackaroo (*Flight*, July 12), I fell to wondering why the aircraft should have been so named. The dictionary—defining jackaroo as "a young man living as an apprentice on a sheep station, or otherwise acquainting himself with colonial life"—doesn't help much. Is there perhaps some special significance in the name, known only to the Wiltshire School of Flying?

Teddington, Middx. ROBERT GREEN.

Modern Approach Radar

I CAN assure your correspondent Mr. F. H. Taylor that I am well aware of the existence of the excellent S.T. & C. precision approach radars at Thurleigh, and also, I believe, at Defford, Zurich, Amsterdam, and in service with the Royal Canadian Navy in Nova Scotia. I did not mention this equipment in my previous letter as I was under the impression that production ceased after these five units were manufactured.

If I have been misinformed I hope that Standard Telephones and Cables (and Mr. Taylor) will forgive me for this omission.

New Barnet, Herts. J. M. WILDE.

Historic Hangars

SURELY the first hangar erected for civil flying was at Kill Devil Hills near Kitty Hawk, North Carolina, by Wilbur and Orville Wright. They housed their famed biplane there in the autumn of 1903 ready for flying trials on December 14 and 17. There cannot be one of earlier vintage, and their aircraft was used for civilian use, since there was no military aviation with heavier-than-air aircraft.

It will interest your readers to know that during a visit to Kill Devil Hills on June 15 I saw this hangar and the Wright brothers' adjoining workshop and sleeping quarters. They have been reconstructed with great fidelity to the originals and the workshop filled with replicas of the brothers' books, tools, kitchen utensils, beds, furniture, etc.

This was in fact done on a suggestion of mine laid before the Kill Devil Hills Memorial Society during my visit there in the summer of 1953 when they were seeking ideas for the Golden Jubilee for December 1953. I was informed that it was all completed ready for that memorable commemoration.

Saltdean, Sussex. WILLIAM COURTENAY.

Airliner Crew Complements

WE welcome the publication by *Flight* of Mr. George Petty's article, "The Future of the Flight Engineer" [July 5], and subscribe in full to the clear exposition for the need for specialized engineer officers' services within existing crew complements, and in particular within crew complements for aircraft of the future.

This Association has, over the years, given considerable attention to the maintenance of the highest safety standards in aircraft operations, and has continued to expound to statutory authorities the views of its membership in this connection.

In 1954, discussions took place with the Air Registration Board and, as a result of considerable technical research, the Association suggested that the Board could well accept the American principle, namely, that aircraft in excess of 80,000 lb all-up weight should have a flight engineer's station.

The all-up weight factor was rejected by the Board, who proposed a formula which would allow manufacturers, operators and the A.R.B. to predetermine C. of A. requirements at an early design-stage. The Association produced a formula, and this was submitted for the consideration of the Board.

They rejected it on the grounds that there would be marginal cases arising, although the Board agreed that there was much to commend it; they maintained that the real answer was for their own staff to make up its mind earlier, and that this would be done in the future.

Arising out of the dispute over engineers in Britannia 100 aircraft, it is the Association's opinion that had the A.R.B. accepted the formula the dispute would not have arisen; secondly, the inference to be gained (from our previous remarks) is that the question of the issue of C. of A. minimum crew requirements for specific types of aircraft is always subject to delay. This is emphasized by the report of the Court of Inquiry, which also levels criticism in the direction of the A.R.B. in this regard.

The Association has contended that more adequate consideration to crew-complement requirements should be given by the appropriate authorities at the blueprint stage of aircraft design.

Transport aircraft are now larger and faster and are required to fly at higher altitudes, through more complex traffic patterns and through all vagaries of the weather on a tight commercial schedule. To ensure the safe transit of upwards of 100 passengers a wide total unduplicated knowledge must be available on the flight deck. This has led in the past to the introduction into the crew of the specialist flight engineer and the specialist navigator, both of whom relieve pilots of a proportion of the complexities, thus helping to ensure that an all-important essential in all forms of transport is observed, namely, a vigilant look-out.

The Association does not desire to impede technological progress, but it considers that the need for specialization amongst aircrew members is in no way reduced, as automatic devices have not yet assumed (and show no signs of assuming) the knowledge and work undertaken by the specialist crew member.

Considerable importance is attached, arising out of recent official reports, to work-load, and in particular to pilots' work-load. Emphasis has been given to the need for greater vigilance on the part of pilots, and it is a fact that the air is now becoming congested. The subject of congestion and collision alone warrants serious study.

The Association must, therefore, reiterate its belief that in order to achieve safety standards satisfactory to the fare-paying passengers upon whom civil aviation depends, greater emphasis must be shown and a wider view taken by those concerned with civil aviation on the all-important subject of crew complement requirements.

As previously stated, the Association is in complete accord with the fundamental principles expounded in the article in question. Whereas in the case submitted by Mr. Petty some preference has been shown to the economics evolving from the carriage of the flight engineer, there is also a corresponding case which can be submitted, based essentially on safety standards in operation.

London, E.1. J. G. K. GREGORY,
Secretary, Air Section, the Merchant Navy and Air Line Officers Association.

Maltese Cross

ON page 888, June 28, you caption a picture as a Shackleton crossing the entrance to the Grand Harbour in Malta. Actually it was crossing the entrance to Sliema Creek (Marsamxett Harbour is the local name). The Grand Harbour is the other side of Valetta, shown in the foreground. Incidentally, "Takali" airfield is locally spelt Ta-Qali.

London, S.W.5. GEOFFREY DORMAN.

"101 Nights"

TO reach members of Bomber Command past and present, especially members of 101 Squadron, may I beg some correspondence space?

Many R.A.F. personnel have sought signed copies of my novel *101 Nights*, set on 101 Squadron during the war. Copies cannot be bought direct from the publisher (Cassell), but to readers desiring it I will gladly arrange for them to get a signed copy if they will write to me c/o Australia House, London, W.C.2.

London, W.C.2. RAY OLLIS.

FORTHCOMING EVENTS

July 26. R.N.A.S. Culdrose, Cornwall: At Home.
July 27-Aug. 5. National Gliding Championships, Lasham.
Aug. 7. Air-Britain: "Vickers Transports, 1920-1960," by P. W. Brooks, and Film Show.
Aug. 5-10. Institute of the Aeronautical Sciences: National Naval Aviation Meeting, San Diego, Cal.
Aug. 18. Swiss Aero Club: International Balloon Meeting, Bâle.
Aug. 18-25. Aeronautical Union of Jugoslavia: International Parachute Contest, Tivat-Boka, Kotorska.
Aug. 23-25. Sporting Flying Club: International Rally, Copenhagen.
Aug. 24-25. Puy Aero Club: International Rally, Le Puy.
Aug. 31. R.N.A.S. Lee-on-Solent, Hampshire: At Home.
Sept. 2-8. S.B.A.C. Show, Farnborough.
Sept. 2-13. Sixth Anglo-American Conference, Great Britain.
Sept. 5. Helicopter Association of Great Britain: Annual Dinner, Dorchester Hotel.
Sept. 9-15. Battle of Britain Week.
Sept. 14-15. Popular Flying Association: Rally, Sywell.
Sept. 15. R.Ae.S. Garden Party, Wisley.
Sept. 19-22. Austrian Aero Club: Innsbruck and Salzburg International Air Rally, Innsbruck.
Sept. 21. R.N.A.S. Abbotsinch, Paisley: At Home.

The Industry

New Hawker Siddeley Directors

AS announced in our news pages last week, Mr. H. G. Herrington, C.B.E., F.R.Ae.S., and Mr. G. C. R. Eley, C.B.E., have been elected to the Board of the Hawker Siddeley Group. (Portraits appear on an earlier page of this issue.)

Mr. Herrington is managing director of High Duty Alloys, Ltd., chairman of Templewood Engineering Co., Ltd., and a director of Hawker Siddeley Nuclear Power Co., Ltd., Hawksley S.M.D., Ltd., Norstel, Ltd., and Aluminium Wire and Cable Co., Ltd. Trained as an engineer at the Coventry Ordnance Works, he served with two engineering companies to obtain practical shop experience and then became assistant to the works manager of an iron and aluminium foundry. He joined High Duty Alloys in 1930 as general manager and in 1937 was appointed to the Board.

Mr. Eley is chairman of the Brush Group, Ltd. (recently merged with the Hawker Siddeley Group), and a member of the Boards of a number of important business and financial organizations, including the Bank of England. During the war he served with Naval Intelligence, and subsequently with the Ministry of Supply as Director of Contracts, in 1946 becoming Director of Overseas Disposals. Two years ago he led the U.K. Trade Mission to Egypt, the Sudan and Ethiopia.

H.P. Appointment

G/C. W. L. Houlbrook, O.B.E., A.M.I.C.E., A.F.R.Ae.S., has joined the staff of Handley Page's sales department, where he will be responsible to G/C. R. C. M. Collard, the sales manager, for military aircraft sales and liaison with the Services. G/C. Houlbrook retired from the R.A.F. at his own request on July 1; he was then a Deputy Director of Technical training at Air Ministry.

Reducing Turn-round Time

ILLUSTRATED below is a particularly useful new type of aircraft loading vehicle, known as the Mercury two-ton high-loading truck and made by Mercury Truck and Tractor Co., Ltd., of The Quay, Gloucester.

As will be seen from the photographs, the extended loading position of the platform is obtained by means of a scissor-action linkage and twin hydraulic rams. The platform, which measures 13ft × 5ft 6in, will lift a load of up to 4,500 lb and can be locked hydraulically at any intermediate level between 5ft 4in and 11ft 6in above the ground. It is raised to its full height in 40 sec and lowered in 20 sec.

In the left view the truck is seen with a wheeled stillage on its platform. This effects maximum time-saving, as the truck can be driven to the aircraft with an empty stillage on its platform and a loaded one in tow. The empty one is raised to receive inward-bound freight and the stillage lowered. The stillage with outward-bound freight is then raised so that the aircraft can be loaded. Finally, the truck is driven away with the inward-bound freight in tow. The method is, of course, equally applicable to aircraft catering supplies, with minimum risk of spilling liquids or breaking equipment.

The truck is powered by a Perkins four-cylinder diesel developing 46 h.p. at 2,400 r.p.m., which gives a speed of 15 m.p.h. Very complete electrical and other equipment is provided, and detail points have been carefully studied—e.g., the front and rear edges of the platform are cushioned with thick Sorbo rubber strip to prevent damage to the aircraft.

The manufacturers state that smaller Mercury vehicles of similar design have been in service with Swissair and T.W.A. for some years past, the former company operating 11 of them for catering supplies alone.

In addition to supplying a wide standard range of vehicles for various airfield duties, Mercury offer a complete design, development and manufacturing service for specialized types of vehicle.

New Avro Canada Company

THE formation of a ninth company in the A. V. Roe Canada, Ltd., group was announced by the Hawker Siddeley Group in London last week. The new company, Canadian Thermo Control Co., Ltd., has been established to sell and service refrigeration equipment under a licence agreement with Thermo King Corporation and Thermo King Railway Corporation of Minneapolis, Minn. The licence gives A. V. Roe Canada exclusive rights to sell in all countries of the British Commonwealth and on a non-exclusive basis to other parts of the world, with the exception of the United States, Mexico, Central America and some South American countries.

IN BRIEF

Rollason Aircraft and Engines, Ltd., of Croydon Airport, have been given the distribution agency for the Thruxton Jackaroo Tiger Moth conversion for the United Kingdom.

* * *

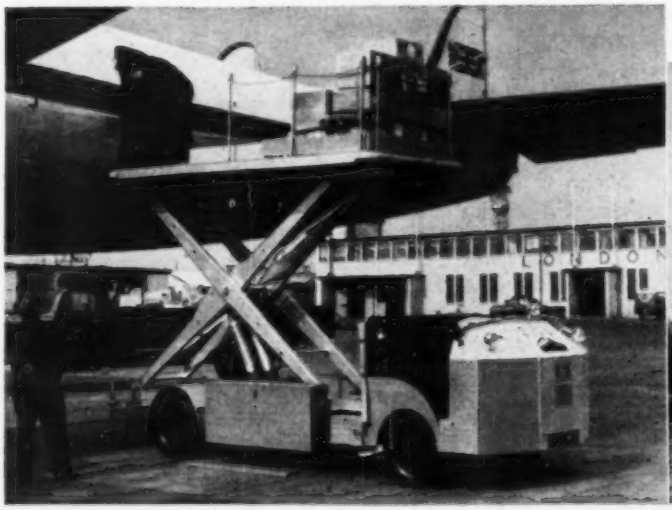
Mr. F. Clarke, a director of Airspeed Precision (London), Ltd., has joined the Boards of Saben Hart and Partners, Ltd., and of Quicktho, Ltd.

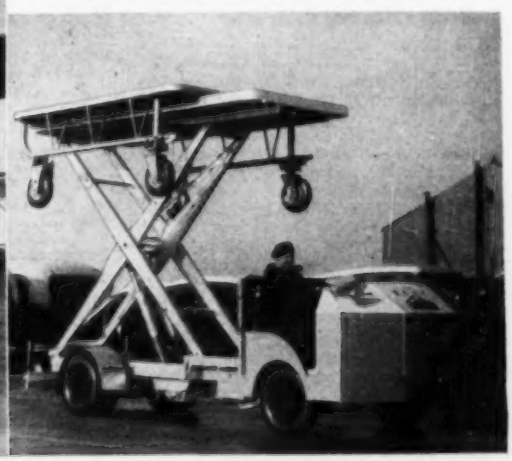
* * *

B.M.B. (Sales), Ltd., High Street, Crawley, Sussex, announce that they are now sole selling agents for S.B.W. (Coldheading), Ltd., specialists in the manufacture of rivets and pins for the radio and electronics industry, aircraft construction and instruments.

* * *

Mr. A. E. Cain, who since 1949 has been responsible for the Bristol Aeroplane Company's laboratory dealing with guided-weapon electronics and instrumentation in this country and Australia, has joined the Board of Dekko Cameras, Ltd. (Telford Way, London, W.3), where he will be in charge of their new electronics and instrumentation department.





The Mercury high-loading truck—described in a news-item above—in service with B.O.A.C. at London Airport.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

First Royal Inspection

ON July 18 the Duke of Gloucester, who holds the rank of Air Chief Marshal, reviewed and took the salute at a passing-out parade at R.A.F. Jurby, Isle of Man, and presented the Sword of Merit to Officer Cadet Dennis N. Ing. The Duke, who thus became the first member of the Royal Family to have reviewed a passing-out parade at Jurby, flew there in a Heron of the Queen's Flight.

No. 99 Sqn. Standard

A STANDARD is to be presented to No. 99 Squadron by Air Chief Marshal Sir Ronald Ivelaw-Chapman at R.A.F. Lyneham on September 27. Former squadron members are cordially invited to attend the ceremony, which begins at 1100 hr, and those wishing to do so should contact the Adjutant, No. 99 Sqn., R.A.F. Station Lyneham, Chippenham, Wilts (tel. Bradenstoke 271, ext. 61).

Air Rank Ratios

GIVING figures in Parliament last week for the ratio of air officers to other ranks on July 1, 1939, 1945, 1951 and 1957, the Under-Secretary of State for Air, Mr. Charles Orr-Ewing, said that the ratios were: 1939, 1 to 1,174; 1945, 1 to 2,046; 1951, 1 to 975; and 1957, 1 to 761. When asked why there could not be a corresponding reduction in air marshal posts dealing with manned aircraft when new ones were established to deal with guided weapons, Mr. Orr-Ewing said that "a most careful survey" of all air ranks was being conducted and the points raised would be considered.

R.A.A.F. Re-equipment

ON his return last week from a visit to the United States the Australian Minister of Defence, Sir Philip McBride, said he would make a full report to the Cabinet on what types of American fighter and transport aircraft might be suitable for re-equipping the R.A.A.F. Fighters would probably be built in Australia but transport aircraft would "probably have to be purchased."

Sir Philip said he did not consider that the long-range bombers the Americans were building had a place in Australia's defence plan at the moment. "I think Canberras are still sufficient," he added.

Coastal Command Record

TO commemorate Coastal Command's 21st anniversary and its achievements during the Second World War, a stained-glass window was unveiled by Air Chief Marshal Sir Frederick W. Bowhill at Northwood on July 13 [photographs of this ceremony were published in *Flight* last week (page 70) and a description of the window appeared in the issue of July 12, page 62] and a large-size 32-page brochure —*Coastal Command's War Record, 1939-45* —has been published. This contains a description of the window with a full colour plate illustration and gives complete details, in tabular form, of all Coastal Command operations during the war.

The brochure costs 5s to members of the Coastal Command Reunion Association and 10s to non-members, plus postage and packing (1s 4d). There is also available, in a similar art cover, a colour plate and description of the commemorative window (2s 6d plus 6d postage). Copies may be obtained on application to S/O. B. E. Lumb, Headquarters Coastal Command, R.A.F. Northwood, Middx.

R.A.F. Reserves Club

MEMBERSHIP of the R.A.F. Reserves Club, 14 South Street, London, W.1, is now open to officers or ex-officers of the R.A.F., R.Aux.A.F., R.A.F.V.R., R.A.F.O., R.F.C. and R.N.A.S.; to men in the aircraft and air transport industries, or otherwise associated with aviation; to ex-wartime N.C.O. aircrew; and to ex-officers of the W.R.A.F., Princess Mary's R.A.F. Nursing Service, and the W.A.A.F. Subscriptions are £5 5s (town members), £2 12s 6d (country) and £1 1s (overseas), for male members; and £3 3s (town), £2 2s (country) and £1 1s (overseas) for ladies. There is no entrance fee.

Temporary membership facilities are available at the R.A.F. Reserves Club, which also has a reciprocal arrangement with the A.B.A.C. whereby members may visit aero clubs within the Association. Details of both these schemes are available from the club secretary.

F.A.A. Awards

A FULL list has now been issued by the Admiralty of awards to Fleet Air Arm personnel "for distinguished services in operations in the Near East, October to December 1956." Some names have previously been published (in *Flight* for June 21); they are included in the following complete list:—

O.B.E.: Commander W. C. Simpson, D.S.C., H.M.S. *Eagle* (Staff of F.O.A.C.).

M.B.E.: Lieutenant Commanders G. H. Creese, H.M.S. *Eagle*; J. M. Jones, 895 Sqn.; J. A. C. Morgan, 845 Sqn.; D. A. J. Sheppard, 810 Sqn.; A. M. B. Taylor, H.M.S. *Eagle*.

B.E.M.: Chief Aircraft Artificer R. G. King, 845 Sqn.

Bar to D.S.C.: Lieutenant Commanders M. W. Henley, D.S.C., 893 Sqn.; P. M. Lamb, D.S.C., A.F.C., 810 Sqn.

D.S.C.: Lieutenant Commanders R. L. Eveleigh, 802 Sqn.; C. V. Howard (now Commander), 830 Sqn.

Mentioned in Dispatches: Lieutenant Commanders P. E. Bailey, H.M.S. *Eagle*; A. A. B. Clark (now Commander), 899 Sqn.; D. A. Fuller, 849 Sqn.; B. H. Harris, H.M.S. *Albion*; J. C. Jacob (now Commander), 845 Sqn.; R. von T. Kettle, 804 Sqn.; D. T. McKeown, 802 Sqn.; M. H. J. Petrie, 892 Sqn.; A. R. Rawbone, A.F.C., 897 Sqn.; J. D. Russell, 800 Sqn.; R. A. Shilcock, 809 Sqn.; J. H. Summerlee, H.M.S. *Eagle*. Chief Aircraft Artificers C. H. Berry, 892 Sqn.; L. Carter, 895 Sqn.; F. N. Davies, 804 Sqn.; P. J. Foley, 802 Sqn.; H. C. C. Huzzey, 810 Sqn. Chief Airman C. H. French, H.M.S. *Eagle*; Aircraft Artificer (O) 1st Class D. Harbin, 895 Sqn. Chief Aircraft Mechanician R. A. Wilson, 800 Sqn. Sick Berth Chief Petty Officers J. W. Bennett, H.M.S. *Theseus*; T. A. Grundy, H.M.S. *Ocean*; Chief Petty Officer Cook (S) C. H. Bell, H.M.S. *Albion*; Leading Airmen K. E. Gammer, H.M.S. *Eagle*; G. J. H. Hazel, H.M.S. *Eagle*; Naval Airman 1st Class A. B. Webster, H.M.S. *Eagle*; Sick Berth Attendant B. A. Greenacre, H.M.S. *Eagle*.

O.B.E.: Commander (A) N. H. Bovey, R.N.V.R., formerly Commanding Officer, Channel Air Division, R.N.V.R.

B.E.M.: Chief Aircraft Artificer B. H. Blakeman; Chief Air Fitters (O) S. Reid; and W. A. Venning.

R.A.F. Appointments

BELOW is continued a list of R.A.F. appointments which have recently been announced by the Air Ministry:—

G/C. R. D. Pratt to H.Q., No. 40 Group, for administrative staff duties.

W/C. J. Ellis to R.A.F. Tangmere, for administrative duties; W/C. C. S. Hawley to H.Q., 2nd T.A.F., for air staff duties; W/C. S. J. Popham-Pursey to Air Ministry, for duty in the Department of the Air Member for Supply and Organization; W/C. W. H. Newman to Ministry of Supply; W/C. F. E. McDonnell to H.Q., British Forces, Arabian Peninsular, for movements staff duties; W/C. D. Nelson to Air Ministry, for duty in the Department of the Chief of the Air Staff; W/C. J. D. Mallinson to Ministry of Supply; W/C. J. C. Cracroft-Rice to H.Q., No. 40 Group, for air staff duties; W/C. A. Murray to R.A.F. Akrotiri, for technical duties; W/C. R. A. Field to H.Q., Flying Training Command, for administrative duties; W/C. H. R. Crowley to H.Q., SACLant, for staff duties; W/C. B. Brown to R.A.F. Shawbury, for technical duties; W/C. A. M. Paterson to R.A.F. Upwood, for technical duties; W/C. C. F. Smart to H.Q., Coastal Command, for technical staff duties; W/C. W. E. French to R.A.F. Tengah, for technical duties; W/C. H. H. Sims to H.Q., Transport Command, for technical staff duties; W/C. E. F. Pippett to be Air Attaché at Rangoon (with the acting rank of group captain); W/C. R. F. H. Clerke to Air Ministry, for duty in the Department of the Chief of the Air Staff; W/C. R. D. Doleman to R.A.F. Church Fenton, for flying duties; W/C. C. Dunkerley to H.Q., Home Command, for administrative staff duties; W/C. I. D. N. Lawson to R.A.F. Lyneham, for flying duties; W/C. C. W. McN. Newman to R.A.F. Halton, for administrative duties; W/C. A. J. Picknett to Air Ministry, for duty in the Department of the Chief of the Air Staff; W/C. A. J. Scott to R.A.F. Feltwell, for flying duties; W/C. L. D. Wilson to H.Q., 2nd T.A.F., for air staff duties; Acting W/C. G. A. Mason to R.A.F. Leuchars, for flying duties.

S/L. A. Vicary to R.A.F. Goch, to command (with acting rank of wing commander); S/L. R. I. Gray to Ministry of Supply (with acting rank of wing commander); S/L. D. G. Dunphy to R.A.F. Honington, for technical duties (with acting rank of wing commander).

IN BRIEF

Air Chief Marshal Sir Basil Embry has been appointed honorary representative for the R.A.F. Benevolent Fund in Western Australia.

* * * * *

G/C. H. A. S. Disney, commander of the task force for the new series of nuclear tests at Maralinga, arrived at Edinburgh Airfield near Adelaide on July 16.

* * * * *

Sekkong, the R.A.F. airfield at Hong Kong, has been closed as an economy measure and No. 28 Sqn. (Venoms) transferred to Kai Tak civil airport.

* * * * *

During last year, in making available £568,564 on all forms of assistance, the R.A.F. Benevolent Fund expended over £11,000 in excess of money received from all sources.

* * * * *

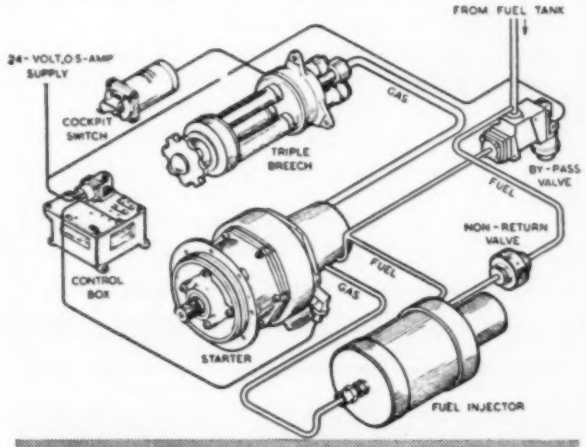
The A.O.C. Malaya, A.V-M. V. E. Hancock, has sent a message of congratulation to No. 194 Sqn. on their 2,000th jungle casualty evacuation.

* * * * *

Mr. G. R. Boak, general secretary of the R.A.F.A., has been appointed to serve as the British representative on the standing orders committee organizing the conference of the World Veterans' Association in West Berlin next October.

30% lighter than any other liquid-fuel starter

BTH's latest contribution to the development of aircraft turbo-starters is this new Iso-Propyl Nitrate starting system—simpler and approximately 30% lighter than any previous design.



- ★ Under 10 seconds starting time
- ★ Less than 1 amp. current used per start
- ★ Fuel automatically and exactly metered for each start
- ★ No air supply needed
- ★ Standard 50-60 gm cartridges used for initiating start.

Following satisfactory tests on the large new Armstrong Siddeley 'Sapphire' engine, the Ministry of Supply have placed substantial orders for this BTH starting system for use in the latest 'Javelin' Fighter.

B T-H

BRITISH THOMSON-HOUSTON

THE BRITISH THOMSON-HOUSTON COMPANY LIMITED
COVENTRY ENGLAND

Member of the AEI group of companies

A 4958

take a lead

make magnesium alloy castings
come clean . . . and STAY clean

Fluoride Anodising and Surface Sealing of Magnesium

For full information and free advice
on the application of these processes
to all magnesium alloys
write or telephone

Magnesium Elektron Limited

Clifton Junction, Manchester
Tel: Swinton 2511
London Office: 21 St James's Square, SW1
Tel: Whitehall 1040

from MEL

In U.S.A. apply to Magnesium Elektron, Inc., New York 20

MARICON FLEXIBLE HOSE

A BETTER HOSE OF LIGHTER WEIGHT M.O.S. APPROVED FOR LOW PRESSURE FUELLING SYSTEMS

Maricon Hose is fully approved under M.O.S. Specification D.T.D. (R.D.I.) 3951 and is included in S.D.M. No. 101 (Issue 4) and S.D.M. 183 (Issue 3). Both types A (Non Fire Resistant) and B (Fire Resistant) offer remarkable weight saving advantages as compared with similar hoses and can be supplied in long lengths, or assemblies. Type B has been proved by exhaustive tests to have exceptional fire-resisting qualities. We shall be pleased to supply specification, drawings, and full details on request.

"MARICON" HOSES INCORPORATE "HALLPRENE" SYNTHETIC RUBBERS

MARICON LIMITED, OLDFIELD ROAD, HAMPTON, MIDDLESEX
(MOLESEY 2180)

KPS

Kiveton Park Steel & Wire Works Limited

Kiveton Park, near Sheffield

Tele. : Kiveton 252
Telegrams : Brightalloy, Phone, Kiveton Park

Manufacturers of

High Grade Steels

for the
Aircraft, Automobile and General Engineering Trades

Specialities :

Bright drawn and centreless ground alloy and carbon steel bars, ⅛"-1" rounds, squares, hexagons, flats and special sections.

Hardened and tempered, annealed or normalised.

Carbon and Alloy cold forging wire suitable for a tensile range of 45/85 tons per sq. inch. Sizes ⅛"-1¼" round.

A.I.D. Approved since 1928, No. 823910/28

STOCKISTS AND DISTRIBUTORS OF AIRCRAFT STEELS

Messrs. J. PENNY & SON · OLDBURY · BIRMINGHAM

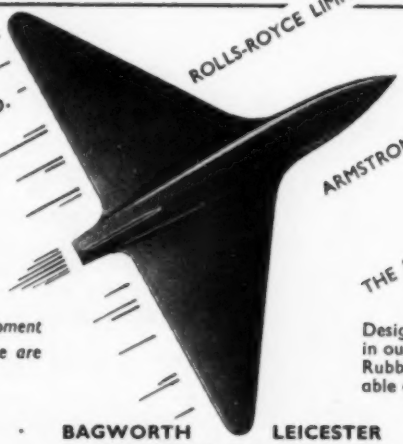
JENKS BROTHERS LIMITED

Britool Works, Bushbury, Wolverhampton.

PR

Rubber Components . . .

are used by the leading manufacturers of Aero Engines



Famous names in Aero Engine development whose confidence in our products we are privileged to enjoy.

Designers and Engineers will be interested in our publication 'Synthetic and Natural Rubbers and their uses'—copies are available on request.

PRECISION RUBBERS LTD · BAGWORTH LEICESTER · Phone: Bagworth 241/2/3

APPROVED A.I.D. AND A.R.B.

Specialists in Precision Mouldings in Natural, Synthetic and Silicone Rubbers to officially approved specifications and to customers specific requirements.

FABRICATION BY FORD

Frank Ford (Aircraft Components) Ltd maintains a modern sheet metal factory and a fully equipped machine shop for fabrication and precision machining of forgings, components and assemblies. Ford fabrications have proved themselves in many of the world's most famous aircraft and aircraft engines—including the Rolls-Royce NENE 103. Should you have any fabrication problems the Company's wide experience is at your disposal. Write for details:—

FRANK FORD

AIRCRAFT COMPONENTS LTD

All enquiries to Registered Office: SOVEREIGN WORKS, LISTER LANE, **HALIFAX,** YORKSHIRE.
Telephone: Halifax 66361 (4 lines)

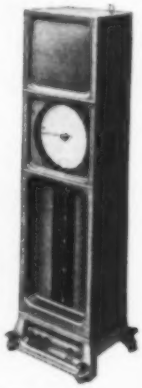
ON THE "BRITANNIA"

SELECTIVE RELAY SWITCHES *for FATIGUE METERS*

Also differential and High Pressure Resistance transmitters combined with switch compatible with H.T.P.

CALIBRATOR MK II C up to 800 knots.

Differential pressure gauges for very light readings.

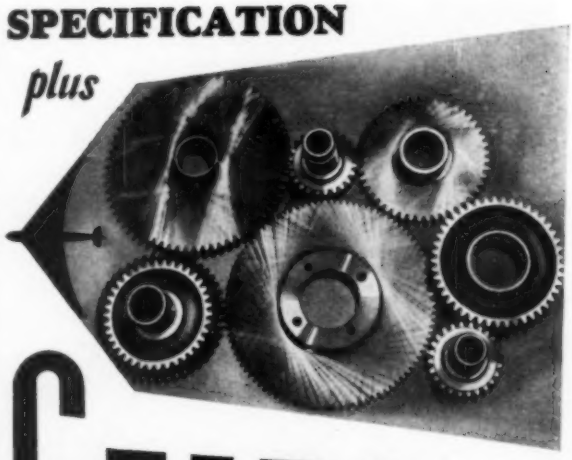


Airspeed indicators including MK 12A.

MUNRO

R. W. MUNRO LTD.
BOUNDS GREEN, LONDON, N.11 *Phone: Enterprise 4422*

SPECIFICATION *plus*



GEARS

FOR HIGHEST MECHANICAL DUTIES TO YOUR LIMITS—DESIGN AND TIME

S. E. OPPERMAN LTD.
Stirling Corner (A.1. Route), Boreham Wood, Herts., England. Phone: Elstree 2021

NEWTON-DERBY

NBD

HIGH FREQUENCY ALTERNATORS
400 to 2400 cycles per second

Our range of H.F. Alternators covers an extensive range of frequencies and outputs up to 15 K.V.A.

We would welcome your enquiries for this class of machine.

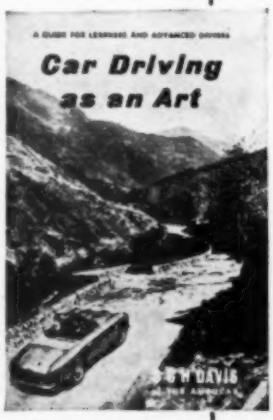
GIVE GENEROUSLY
R.A.F. BENEVOLENT FUND 67 PORTLAND PLACE LONDON, W.1.

Also manufacturers of:-

AUTOMATIC VOLTAGE REGULATORS
•
ROTARY TRANSFORMERS AND CONVERTERS
•
MOTOR GENERATORS

SBAC

NEWTON BROTHERS (DERBY) LTD.
ELECTRICAL PLANT SPECIALISTS
HEAD OFFICE & WORKS: ALFRETON RD., DERBY. PHONE: DERBY 45171 (6 LINES). CABLES: DYNAMO, DERBY
LONDON OFFICE: IMPERIAL BUILDINGS, 56 KINGSWAY, W.C.2. TEL: 2627 HOLBORN



203 pages plus 24 pages of plates

12s 6d net

by post 13s 10d

A new edition of a motoring classic

This famous book, by S. C. H. Davis of "The Autocar," is for learners and advanced drivers. It teaches *roadcraft* as opposed to mere driving. Thoroughly revised and re-illustrated, this edition deals with the driving test, driving in rain, fog and snow, driving for performance, foreign touring, and care and maintenance.

CAR DRIVING AS AN ART

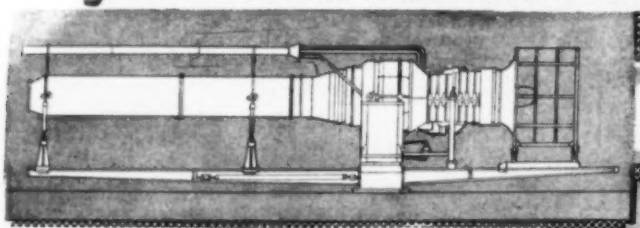
Published for 'The Autocar' by Iliffe & Sons, Ltd Dorset House Stamford St., London, S.E.1

2nd Edition NOW ON SALE
from leading booksellers

CURRAN

NOW OFFER — THE MOST VERSATILE RANGE of AERO ENGINE TEST EQUIPMENT

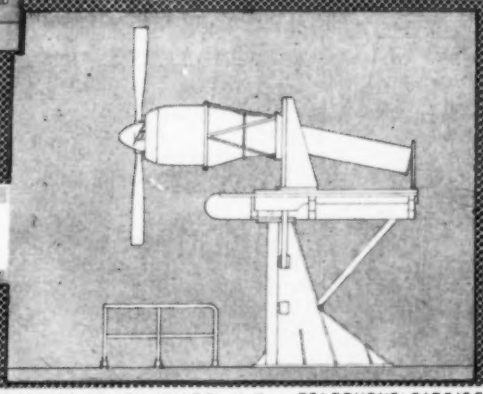
SERIES J TEST STANDS FOR PERFORMANCE TESTING TURBO-JET AERO ENGINES
AVAILABLE IN 4 MODELS



UP TO 30,000 LBS. THRUST

SERIES T TORQUE MEASURING TEST STANDS FOR PERFORMANCE TESTING TURBO-PROP AERO ENGINES

UP TO 10,000 H.P.



JOHN CURRAN LIMITED • MECHANICAL ENGINEERS • CURRAN ROAD CARDIFF SOUTH WALES U.K. • TELEPHONE: CARDIFF 20641

An Improved Design of Pressure Operated Switch

This new Pressure Operated Switch has been designed to cover ranges from 50-5,000 pounds per square inch. The Pressure Unit including the Diaphragm is constructed of stainless steel enabling the Switch to be used on all aircraft fuels, hydraulic fluids and pneumatic systems, including High Test Peroxide and Nitric Acid. The Switch incorporates a Micro Switch and has a three pin plug connection enabling the customer to select either "make" "break" or "change over" contacts.

Vibration: To Des. 1. and G.100
Temp. Range: —54° C to 132° C. Survival —70° C to 150° C.
Contact Rating: 5 amp. 250 volts A.C., 30 volts D.C., 2.5 amps. D.C.
Pressure Range: In ranges between 50 to 5,000 P.S.I. (3.5 to 350 KG/Cm2).
Pressure Connection: ¼" B.S.P. Female.
Electrical Connection: Plessey Plug Mk. IV, CZ/48993.
Mounting Arrangement: 4 holes .199 in. dia. 1.625 in. centres.
Overload Working: 7,500 P.S.I. (525 KG/Cm2).
Proof Pressure: 10,000 P.S.I. (700 KG/Cm2).
Weight: 10 ozs.
Dimensions: Overall Height 3.452". Overall Diameter 2.750".

Visit our Stand No. 280 at The S.B.A.C. Show, Farnborough

NOTE: For high temp. range, alternative electrical connections are required. For further information on this and all Pressure Switch requirements, please write or telephone:

THERMAL CONTROL CO. LTD
MARINE WORKS, SACKVILLE ROAD, HOVE, SUSSEX.
Telephone: HOVE 35929/34081

SCHOOL OF GAS TURBINE TECHNOLOGY

POWER JETS (RESEARCH AND DEVELOPMENT) LTD.

An Aero Engine Design Course will be held from 12th—30th August, 1957.

An International Course will be held from 9th—27th September, 1957.

Each Course will include a test of two gas turbine engines.

Full particulars on application to The Principal

SCHOOL OF GAS TURBINE TECHNOLOGY

FARNBOROUGH PLACE, FARNBOROUGH, HAMPSHIRE, ENGLAND *Telephone:* **Farnborough 1300**

We are proud to be linked with the Aircraft Industry . . .

Manufacturers of PRESSINGS in STAINLESS STEEL and other materials, WELDED RINGS, etc., etc.

STEEL STAMPINGS

LIMITED

Cookley Phone: Wolverley 266 **Near Kidderminster** Grams: Stampings, Cookley

KIGASS

HAND PRIMING PUMPS AND ATOMISERS FOR AIRCRAFT
[A.I.D./A.R.B. APPROVED]

* **PRECISION**
* **ACCURACY**
* **RELIABILITY**

Widely used for engine starting. KIGASS are keeping pace with development in the production of low pressure atomisers having applications in Gas Turbine and Rocket Motors.

Manufacturers are finding fresh applications where the consistent output of the KIGASS PRIMERS are invaluable.

KIGASS

ARE KEEPING PACE WITH DEVELOPMENT

KIGASS LTD., 31 REGENT GROVE, LEAMINGTON SPA
Telephone: Leamington Spa 2480/1

Suppliers of **machined** *and* **fabricated components** *in all Plastics and Allied materials to individual requirements. Precision guaranteed.*

UHLHORN BROS. LIMITED EST. 1887

EBONITE (Vulcanite)
RESILON (Synthetic resin bonded paper)
RESILON (Synthetic resin bonded fabric)
COROSITE (Acid resisting material)
GLASS-FIBRE LAMINATES
VULCANISED FIBRE (Red, Black or Grey)
FEROBESTOS, ETC.

Telephone: CLE 0145/9 Telegrams: UHLHORN, AVE, LONDON

UHLHORN BROS. LTD.,
53 CITY ROAD, LONDON, E.C.1

D. NAPIER AND SON, LTD.
LUTON AIRPORT, BEDS.

AIRCRAFT DE-ICING FLIGHT TRIALS

SENIOR TECHNICAL ASSISTANT required primarily to superintend the flight testing and analysis of flight trial results on de-icing programmes. Applicants should have some previous technical experience in some field of flight testing and be fit and willing to fly. Experience in the problems of aircraft ice formation an advantage, together with good basic (although not advanced) physics. Must be capable of compiling reports, discussing results, and initiating and programming new tests. Apply to **Dept. C.P.S. 336/7, Strand, W.C.2, quoting ref. F 810F.**

WANTED BY
EASTERN PROVINCIAL AIRWAYS LIMITED
GANDER · NEWFOUNDLAND · CANADA

One **HELICOPTER PILOT** with at least 1,000 hours bush experience or the equivalent. Type of helicopter: Bell 47 J.
Starting Salary: $800.00 (equivalent approx. £302) per month.

One Licensed HELICOPTER ENGINEER.
Starting Salary: $400.00 (equivalent approx. £151) per month.

One or more Licensed AIRCRAFT ENGINEERS for Fixed Wing Aircraft including Beavers, Otters, Canso, etc.
Starting Salary: $350.00 (equivalent approx. £132) per month.

All Engineers required to have 5 years' experience in Aircraft Industry.

Interested parties reply to the undermentioned for full particulars:

MR. ANDREW CROSBIE
HOLMWOODS & BACK & MANSON LIMITED
85 GRACECHURCH STREET, LONDON, E.C.3
Telephone: Mansion House 4471-7

ENGLISH ELECTRIC AIRCRAFT
FLIGHT TEST and INSTRUMENTATION

The Aircraft Division has an extensive programme of flight testing on a large number of pre-production P.1B supersonic fighters, in addition to the flight testing of the prototypes, and applications from flight test and instrumentation engineers are required for this expanding department. It is emphasised that with the production order recently placed for the P.1B, continuity of employment is assured.

FLIGHT TEST ENGINEERS should have H.N.C., a degree or higher qualifications and preferably some years experience in this type of work.

INSTRUMENTATION ENGINEERS should have O.N.C. or better and some years experience in instrumentation techniques or similar work. The laboratory is fully equipped and modern techniques of instrumentation are employed.

The Division is located at Warton Aerodrome near the pleasant residential area of Lytham St. Annes, and interested applicants should write with full details to

Dept. C.P.S., Marconi House, 336/7 Strand, W.C.2, quoting reference F 1712D.

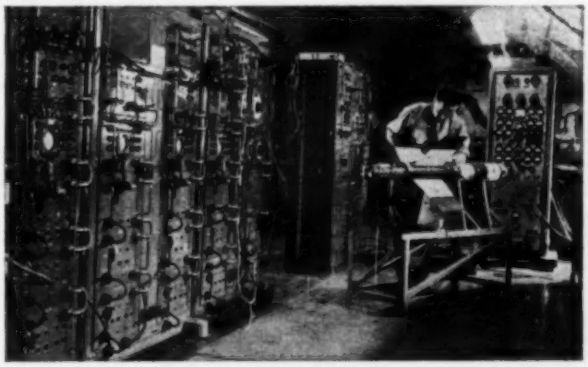
Fairey Aviation want Engineers and Scientists to work on the design and development of:-

GUIDED WEAPONS, ELECTRONIC EQUIPMENT, AND PRECISION ELECTRO-MECHANICAL PRODUCTS

FAIREY's widespread activities offer numerous opportunities for soundly-qualified men with the right training or experience. If you are confident that you have the qualifications and keenness to join the team that, among other achievements, produced FIREFLASH, Britain's first production guided weapon, write to the address below: give your full details, including your own preference for the more specialised types of work.

Vacancies exist for Aerodynamicists · Physicists · Electronic Engineers · Instrument Design Engineers · Mechanical Test Engineers Stressmen · Graduates (in Engineering or Science) · Draughtsmen (Electronic, Jig and Tool, Mechanical Design and Detail).

The illustration shows functional testing of a FIREFLASH Guided Weapon in the Laboratories — one aspect only of the interesting and varied work awaiting you at Fairey Aviation.



THE FAIREY AVIATION COMPANY LTD
Weapon Division
CRANFORD LANE · HESTON · NR. HOUNSLOW · MIDDX.

FLIGHT and AIRCRAFT ENGINEER

PRESS DAY — *Classified advertisement "copy" should reach Head Office by* FIRST POST THURSDAY *for publication in the following week's issue subject to space being available.*

CLASSIFIED ADVERTISEMENTS

Advertisement Rates. 5/- per line, minimum 10/-, average line contains 6-7 words. Special rates for Auctions, Contracts, Patents, Legal and Official Notices, Public Announcements, Public Appointments, Tenders 6/- per line, minimum 12/-. Each paragraph is charged separately, name and address must be counted. All advertisements must be strictly prepaid and should be addressed to FLIGHT Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1.

Postal Orders and cheques sent in payment for advertisements should be made payable to Iliffe & Sons, Ltd., and crossed & Co.

Trade Advertisers who use these columns regularly are allowed a discount of 5% for 13, 10% for 26 and 15% for 52 consecutive insertion orders. Full particulars will be sent on application.

Box Numbers. For the convenience of private advertisers, Box Number facilities are available at an additional charge for 2 words plus 1/- extra to defray the cost of registration and postage, which must be added to the advertisement charge. Replies should be addressed to "Box 0000, c/o Flight," Dorset House, Stamford Street, London, S.E.1.

The Publishers retain the right to refuse or withdraw advertisements at their discretion and do not accept liability for delay in publication or for clerical or printer's errors although every care is taken to avoid mistakes.

W. S. SHACKLETON LTD

EUROPE'S LEADING AIRCRAFT BROKERS

are privileged to offer

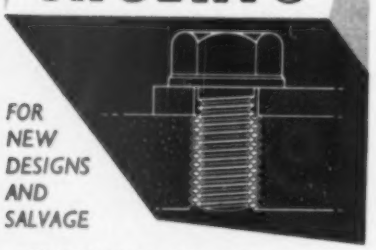
TWO BRISTOL SYCAMORE TYPE 171 Mk. 3 HELICOPTERS

On behalf of the manufacturers, Bristol Aircraft Limited, we are proud to offer their two factory demonstrators which are in immaculate condition and fully furnished in the executive configuration. The total hours since new are only 700 and 800 and both are equipped with VHF. Delivery is immediate and the price only £15,000 and £16,000.

Full particulars from:

W. S. SHACKLETON LTD.
175, PICCADILLY, LONDON, W.1.
Cable: "Shackhud, London."
Tel.: HYDe Park 2448-9

WIRE THREAD INSERTS



FOR NEW DESIGNS AND SALVAGE

CROSS MFG. CO. (1938) LTD
COMBE DOWN, BATH
TEL: COMBEDOWN 2355/8

PRESS NOTICE
AUGUST 9th ISSUE WILL CLOSE FOR PRESS WITH FIRST POST WEDNESDAY, JULY 31st.

AIRCRAFT FOR SALE

VENDAIR OF CROYDON AIRPORT

OFFER

GEMINI Mark 1A. Airframe hours 1,050 since new. Cirrus Minor II engines 230 hours and 80 hours. V.H.F. radio. Recent C. of A.; aircraft in excellent condition. Price £1,900.

AUSTER Mark V. Airframe 850 hours since new, Lycoming engine zero hours since complete overhaul; three seats; new C. of A. Price £1,000.

PROCTOR Mark IV. Airframe 900 hours, engine 300 hours; 4 Rumbold seats; new C. of A. Price £595.

FIVE other aircraft in stock. Vendair, Croydon 5777. [0603

MITCHELL AIRCRAFT, LTD.

Offer for early delivery

RAPIDE Mk. 4, with 12 months C. of A. Engine hours, port 149, stbd. nil. Propeller hours, port 149, stbd. 175. Fitted with 8-9 passenger seats, new upholstery. Radio, STR 9x and Marconi D.F. Colour white and silver with red letters and flash.

FOR further details apply

MITCHELL AIRCRAFT, LTD., The Airport, Portsmouth. Tel. 717641. [0348

TRAVELAIR, LTD.
offer
New Auster Alphas
3/4 seats, performance, economy.
Exceptionally low price of £1,682.
H.P. terms arranged for all aircraft we sell.
Travelair, Ltd.
115 Oxford Street, London, W.1. GER. 3382. [0610

PROCTOR Mk. 4, low hours, ex R.A.F. As is, £100. Box No. 0736. [6881

GEMINI SERIES 3.A with Murphy 5 channel radio. C. of A. to June 1960. £3,500. Denby, 5 Princess Road, Ilkley. Tel. 864 after 6.30 p.m. [0460

ROLLASON AIRCRAFT AND ENGINES, LTD., of Croydon Airport, are known as "The Tiger Moth Specialists." Ring CRO. 5151. [0130

PIPER AIRCRAFT. Tri-pacers, Apaches, Super Cubs. The sole agents for Great Britain are Irish Air Charter Limited, 62, Merrion Square, Dublin. Tel. 62397. [0200

GEMINI 1A. Cirrus Minor II engines, 12 months or 3 years C. of A. Price £1,850. Chipmunk nil hour engine, 12 months C. of A. Price £1,600. Luton Flying Club, Ltd., The Airport, Luton. [6878

MILES Falcon VI, G-AECC, 2nd in 1957 King's Cup air race. Ideal fast touring aircraft with current three year C. of A., 18 months to go, low engine hours. £900. Goodhew Aviation Co., Ltd., Oxford Airport, Kidlington, Oxford. [6869

AIRCRAFT WANTED

W. S. SHACKLETON, LTD., are always in need of civil aircraft of all types to fulfil inquiries at home and overseas.

W. S. SHACKLETON, LTD., 175, Piccadilly, London, W.1. Cable: "Shackhud, London." Tel.: HYDe Park 2448-9. [0073

WANTED to purchase a Tiger Moth aircraft with current C. of A. and at least six months to run. Derby Aviation Limited, Derby Airport. [6859

TIGER Moth, any condition within reason. Details and price to Luton Flying Club, Ltd., The Airport, Luton. [6879

R. K. DUNDAS

offer

TWO EXCELLENT 3-SEATER AUSTER AIRCRAFT

AUSTER V J1 AUTOCRAT—G-AHCO
This aircraft is so well-known that our high recommendation may well be superfluous. With its Cirrus Minor II 100 h.p. engine, two-blade propeller, dual control, it combines easy flying with high performance and comfort. The C. of A. runs to February 1958. It is finished in silver and blue, with fawn leather upholstery.

AUSTER V—G-ANIF
Well maintained and fitted, this plane is highly recommended for its really excellent condition. Finished in blue and silver, it has brand new red leather upholstery, artificial horizon, directional gyro, dual controls, aerobatic seats, navigation and cockpit lights, cabin heater, first-aid kit and fire extinguisher; Lycoming 130 h.p. engine. C. of A. till March next year.

Both aircraft can be viewed at Yeadon Aerodrome, at any time, or by special appointment around London.

We have, of course, many other aircraft available.

R. K. DUNDAS, LTD.
59 St. James's Street, London, S.W.1
Tel.: HYDe Park 3717
Cables: "Dundas Aero," Piccy, London

★ FOR THE CLUB FLYER ★

FLYING HELMET
No. 103
35/-

Leather Flying Helmet for the Club Flyer. Suitable for use with flat type Gosport Tubes. C/No. 214.
Weight 8 ozs. Brown only. Sizes 6½ in. to 7½ in.
* Gosport tube C/No. 214 22/6.
* Helmets complete with Gosport Tubes, 53/- per set.

EX-R.A.F. SUITS, SUMMER FLYING Part used *(Personal Shoppers only)* **39/6**

R.A.F. ANTI-GLARE SUN SPECTACLES
Complete with strong case, 22/6 post free.

Terms to Flying Clubs

Illustrated leaflet on request.
Trade supplied.

D Lewis LIMITED

(Dept. F), 124 Great Portland St., London, W.1
Tel. MUSeum 4314. Grams., Aviakit, Wesdo, London.

Open all day Saturday.

AIRCRAFT ACCESSORIES AND ENGINES

A. J.W. (INSTRUMENTS), LTD.

ALL types of aircraft instruments overhauled. Special test instruments made to your requirements. Particulars on request of our Magnetizer, Demagnetizer and Sureflash—compact—efficient and inexpensive.

A. J.W. (Instruments), Ltd., Gatwick Airport, Horley, Surrey. Tel. Horley 1420 and 1510 (Ext. 38, 105/6). [0268

ROLLASON AIRCRAFT AND ENGINES, LTD., CRO. 5151. For all Tiger Moth, Gipsy Major, Gipsy Queen and Gipsy Six spares. Specialists in the overhauling of Gipsy engines. [0131

LYCOMING 50 h.p. complete with prop. New condition. £45. Cirrus Min., time exp. £65. Queen II, 200 hours since new. £120. Proctor propeller, low time. £45. Box No. 0732. [6880

PHILLIPS & WHITE, LTD., offer from stock Instruments and instrument parts. Navigational equipment, electrical components, airframe parts and hydraulic components and parts. Engine spares for de Havilland Gipsy Major and Queen series, also Armstrong Siddeley Cheetah IX, X, XV spares. Stock lists available. 61, Queen's Gardens, London, W.2. Tel.: Ambassador 8651, 2764. Cables: Gyair, London. [0466

ENGINE Overhauls. Hants and Sussex Aviation Limited offer Britain's most comprehensive engine complete overhaul service, magneto overhaul service, and component and spares supply. De Havilland Gipsy range, Armstrong Siddeley Cheetah range, Cirrus range, Lycoming, Scarab and Continental. Most types available on exchange. Engines, components and spares shipped to all parts of the world. Address: The Airport, Portsmouth. Phone 73947. [0711

PUBLIC ANNOUNCEMENTS

AIR TRANSPORT ADVISORY COUNCIL

THE AIR TRANSPORT ADVISORY COUNCIL give notice that they have received the undermentioned applications to operate scheduled air services:—

APPLICATION No. 1368. From British European Airways Corporation of Keyline House, Ruislip, Middlesex, for a Normal Scheduled Service with Viscount aircraft and later with Vanguard aircraft for the carriage of passengers, supplementary freight and mail between London and Klagenfurt with an intermediate optional traffic stop at Munich at a frequency according to traffic demand for a period of 10 years, from 1958.

APPLICATION No. 1369. From Eagle Airways, Ltd., of 40, Edgware Road, London, W.2, for a Normal Scheduled Service with Viscount aircraft for the carriage of passengers, supplementary freight and mail between London Airport and Reykjavik with intermediate optional traffic stops at Manchester and/or Prestwick at a frequency of two return flights per week increasing according to traffic demand for a period of 10 years, from October, 1957.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [6871

SHORT AVIATION
for
D. H. RAPIDE SPARES
BRAND NEW—EX STOCK—IMMEDIATE DELIVERY
HIGHLY COMPETITIVE PRICES
TIGER MOTH SPARES
IN QUANTITY—EX STOCK—BRAND NEW—VERY LOW PRICES
R. A. SHORT AVIATION, WHYTELEAFE, SURREY. PHONE: UPLANDS 0211/2

OUR HELICOPTERS FLY ALL OVER THE WORLD
Our fleet of helicopters is at your disposal anywhere in the world, any time.
We also run a training school for pilots and engineers on Bell 47 and Sikorsky S55 helicopters Ask for further details from:
OSTERMANS AERO, STOCKHOLM 7, SWEDEN
Cables: Ostermanaero, Stockholm

UNIVERSAL FLYING SERVICES LTD.
A.R.B. APPROVED FOR
C. of A. OVERHAULS
REPAIRS
CONTRACT MAINTENANCE
ALSO
FLYING TUITION
M.C.A. APPROVED COURSES
AIRCRAFT HANGARAGE
FAIROAKS AERODROME
CHOBHAM (WOKING) SURREY
TEL: CHOBHAM 375

SENIOR STRESS ENGINEERS
Starting Salaries £1200/£1700
Qualified men interested in employment within the above starting range, carrying scope for advancement, should enquire in confidence for further details.
Modern housing available convenient to Works, Schools, and Shopping Centres.
Duties cover work on special projects associated with Aircraft Design and Development. Previous experience in this field is not essential for applicants with sound technical background.
Send full particulars age, experience and convenient dates for interview to **S/A. Box No. 0592, c/o "Flight".**

AMERICAN K20 AIRCRAFT CAMERA in fitted carrying case F4.5 lens
£15 . 0 . 0
Films available. K24, F24, F52, K8AB and other cameras and all accessories available from stock write:—
Air Survey Dept.
Harringay Photo Supplies
423 Green Lanes - - London, N.4
MOUntview 5241/2

The . . .
British Air Line Pilots Association
95 MOUNT STREET, W.1
Tel.: Grosvenor 6261
Membership open to all commercial and Service Pilots. For full details concerning objects and particulars of membership please write to Secretary

PUBLIC APPOINTMENTS

MINISTRY OF TRANSPORT AND CIVIL AVIATION

AIR TRAFFIC CONTROL OFFICERS

APPLICATIONS are invited from men and women for Grade III posts with prospects of pensionable appointment. Age at least 23 and under 35 on 1st June, 1957. Candidates must have had a good general education, i.e. normally, General Certificate of Education, with passes in English and mathematics or science or an equivalent qualification. Necessary experience, preferably recent, is (i) as aircrew in civil air transport, preferably as pilot or navigator with experience in the United Kingdom, or (ii) as pilot or navigator in H.M. Forces, preferably with considerable air traffic control experience; but candidates without aircrew experience will be considered if they have considerable practical experience of air traffic control duties. The following will be advantages (i) A.F.R.Ae.S., (ii) pilot's or navigator's licence issued by the Ministry, (iii) good knowledge of civil aviation legislation and practice, (iv) knowledge of radio and radar aids, (v) knowledge of a modern European language. Air Traffic Control Officers are required to serve anywhere in the United Kingdom, and are liable to tours of duty overseas. Starting salary (London): £675 at age 23 to £970 at age 30 or over. Maximum salary for Grade III £1,315. Somewhat lower in Provinces. Women's salaries at present somewhat lower but being improved under Equal Pay Scheme. Promotion prospects to Grade II (maximum salary £1,550) and Grade I (maximum salary £1,690). Particulars and application forms from the Secretary, Civil Service Commission, Burlington Gardens, London, W.1, quoting No. 4735/57. Complete applications should be returned by 9th August, 1957 [6868

ASSISTANT Engineers Grade II required by EAST AFRICA HIGH COMMISSION Directorate of Civil Aviation on probation for pensionable employment. Gross salary according to age and qualifications up to £1,173 a year in scale £813 rising to £1,341 a year. Outfit allowance £30. Free passages. Liberal leave on full salary after each tour 30-36 months. Candidates, who should hold at least two second year and preferably one third year C. & G. Certs. in Telecomms. Principles or Radio, must have had a minimum of three years' experience in the erection and maintenance of ground station transmitters, radio and radar navigational aids and aerial systems. They should have up-to-date knowledge of workshop practice and a knowledge of teleprinter and perforator equipment or Diesel electric power plant maintenance would be an advantage. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/42260/FE. [6864

AIRCRAFT FERRYING

FOR delivery and ferrying of aircraft contact Overseas Air Transport, Ltd., 22, Broad Street, St. Helier, Jersey, Channel Islands. [6723

AERIAL PHOTOGRAPHY

MORSE Film Developing Units and Film Dryers; Continuous Film Printers; Argon and Mason Contact Printers; Water Supply Kits; Glazing Machines: F.24 Spiral and Spool Developing Outfits; K.17; F.52; F.49; and F.24 Cameras, Mounts, Lenses, Magazines, Controls, Vacuum Pumps, Motors and Spares for above Cameras; 16 m/m and 35 m/m Cameras, Projectors and Spares. Also large quantity of Aerial Film (all sizes). A. W. Young, 47, Mildenhall Road, London, E.5. Tel.: AMHerst 6521. [0290

COAXIAL CONNECTORS UG TYPE
21-B/U, 38/U, 290/U etc.
according to JAN and MIL specifications for aircraft etc.
Full list available. Send your requirements.
N.A.R. Agencies Ltd.
40 King's Road, London, S.W.3

AIRCRAFT SPRING WASHERS

TO B.S. SPECIFICATION S.P.47
CROSS MFG. CO. (1938) LTD., COMBE DOWN, BATH

FLIGHT and AIRCRAFT ENGINEER

PRESS DAY — *Classified advertisement "copy" should reach Head Office by* FIRST POST THURSDAY *for publication in the following week's issue subject to space being available.*

CLASSIFIED ADVERTISEMENTS

Advertisement Rates. 5/- per line, minimum 10/-, average line contains 6-7 words. Special rates for Auctions, Contracts, Patents, Legal and Official Notices, Public Announcements, Public Appointments, Tenders 6/- per line, minimum 12/-. Each paragraph is charged separately, name and address must be counted. All advertisements must be strictly prepaid and should be addressed to FLIGHT Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1.

Postal Orders and cheques sent in payment for advertisements should be made payable to Iliffe & Sons, Ltd., and crossed & Co.

Trade Advertisers who use these columns regularly are allowed a discount of 5% for 13, 10% for 26 and 15% for 52 consecutive insertion orders. Full particulars will be sent on application.

Box Numbers. For the convenience of private advertisers, Box Number facilities are available at an additional charge for 2 words plus 1/- extra to defray the cost of registration and postage, which must be added to the advertisement charge. Replies should be addressed to "Box 0000, c/o Flight," Dorset House, Stamford Street, London, S.E.1.

The Publishers retain the right to refuse or withdraw advertisements at their discretion and do not accept liability for delay in publication or for clerical or printer's errors although every care is taken to avoid mistakes.

W. S. SHACKLETON LTD

EUROPE'S LEADING AIRCRAFT BROKERS

are privileged to offer

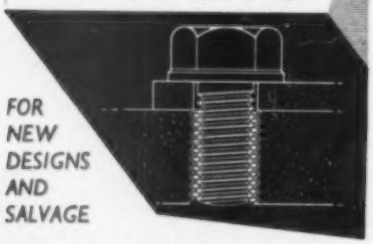
TWO BRISTOL SYCAMORE TYPE 171 Mk. 3 HELICOPTERS

On behalf of the manufacturers, Bristol Aircraft Limited, we are proud to offer their two factory demonstrators which are in immaculate condition and fully furnished in the executive configuration. The total hours since new are only 700 and 800 and both are equipped with VHF. Delivery is immediate and the price only £15,000 and £16,000.

Full particulars from:

W. S. SHACKLETON LTD.
175, PICCADILLY, LONDON, W.1.
Cable: "Shackhud, London."
Tel.: HYDe Park 2448-9.

WIRE THREAD INSERTS



FOR NEW DESIGNS AND SALVAGE

CROSS MFG. CO. (1938) LTD
COMBE DOWN, BATH
TEL: COMBEDOWN 2355/8

PRESS NOTICE
AUGUST 9th ISSUE WILL CLOSE FOR PRESS WITH FIRST POST WEDNESDAY, JULY 31st.

AIRCRAFT FOR SALE

VENDAIR OF CROYDON AIRPORT

OFFER

GEMINI Mark 1A. Airframe hours 1,050 since new. Cirrus Minor II engines 230 hours and 80 hours. V.H.F. radio. Recent C. of A.; aircraft in excellent condition. Price £1,900.

AUSTER Mark V. Airframe 850 hours since new; Lycoming engine zero hours since complete overhaul; three seats; new C. of A. Price £1,000.

PROCTOR Mark IV. Airframe 900 hours, engine 300 hours; 4 Rumbold seats; new C. of A. Price £595.

FIVE other aircraft in stock. Vendair, Croydon 5777. [0603

MITCHELL AIRCRAFT, LTD.

Offer for early delivery

RAPIDE Mk. 4, with 12 months C. of A. Engine hours, port 149, stbd. nil. Propeller hours, port 149, stbd. 175. Fitted with 8-9 passenger seats, new upholstery. Radio, STR 9x and Marconi D.F. Colour white and silver with red letters and flash.

FOR further details apply

MITCHELL AIRCRAFT, LTD., The Airport, Portsmouth. Tel. 717641. [0348

TRAVELAIR, LTD.
offer
New Auster Alphas
3/4 seats, performance, economy.
Exceptionally low price of £1,682.
H.P. terms arranged for all aircraft we sell.
Travelair, Ltd.
115 Oxford Street, London, W.1. GER. 3382. [0610

PROCTOR Mk. 4, low hours, ex R.A.F. As is, £100. Box No. 0736. [6881

GEMINI SERIES 3.A with Murphy 5 channel radio. C. of A. to June 1960. £3,500. Denby, 5 Princess Road, Ilkley. Tel. 864 after 6.30 p.m. [0460

ROLLASON AIRCRAFT AND ENGINES, LTD., of Croydon Airport, are known as "The Tiger Moth Specialists." Ring CRO. 5151. [0130

PIPER AIRCRAFT. Tri-pacers, Apaches, Super Cubs. The sole agents for Great Britain are Irish Air Charter Limited, 62, Merrion Square, Dublin. Tel. 62397. [0200

GEMINI 1A. Cirrus Minor II engines, 12 months or 3 years C. of A. Price £1,850. Chipmunk nil hour engine, 12 months C. of A. Price £1,600. Luton Flying Club, Ltd., The Airport, Luton. [6878

MILES Falcon VI, G-AECC, 2nd in 1957 King's Cup air race. Ideal fast touring aircraft with current three year C. of A., 18 months to go, low engine hours. £900. Goodhew Aviation Co., Ltd., Oxford Airport, Kidlington, Oxford. [6869

AIRCRAFT WANTED

W. S. SHACKLETON, LTD., are always in need of civil aircraft of all types to fulfil inquiries at home and overseas.

W. S. SHACKLETON, LTD., 175, Piccadilly, London, W.1. Cable: "Shackhud, London." Tel.: HYDe Park 2448-9. [0073

WANTED to purchase a Tiger Moth aircraft with current C. of A. and at least six months to run. Derby Aviation Limited, Derby Airport. [6859

TIGER Moth, any condition within reason. Details and price to Luton Flying Club, Ltd., The Airport, Luton. [6879

R. K. DUNDAS

offer

TWO EXCELLENT 3-SEATER AUSTER AIRCRAFT

AUSTER V J1 AUTOCRAT—G-AHCO
This aircraft is so well-known that our high recommendation may well be superfluous. With its Cirrus Minor II 100 h.p. engine, two-blade propeller, dual control, it combines easy flying with high performance and comfort. The C. of A. runs to February 1958. It is finished in silver and blue, with fawn leather upholstery.

AUSTER V—G-ANIF
Well maintained and fitted, this plane is highly recommended for its really excellent condition. Finished in blue and silver, it has brand new red leather upholstery, artificial horizon, directional gyro, dual controls, aerobatic seats, navigation and cockpit lights, cabin heater, first-aid kit and fire extinguisher; Lycoming 130 h.p. engine. C. of A. till March next year.

Both aircraft can be viewed at Yeadon Aerodrome, at any time, or by special appointment around London.

We have, of course, many other aircraft available.

R. K. DUNDAS, LTD.
59 St. James's Street, London, S.W.1
Tel.: HYDe Park 3717
Cables: "Dundas Aero." Piccy, London

★ FOR THE CLUB FLYER ★

FLYING HELMET
No. 103
35/-

Leather Flying Helmet for the Club Flyer. Suitable for use with flat type Gosport Tubes. C/No. 214. Weight 8 ozs. Brown only. Sizes 6½ in. to 7½ in.
* Gosport tube C/No. 214 **22/6**.
* Helmets complete with Gosport Tubes, **53/-** per set.

EX-R.A.F. SUITS, SUMMER FLYING Part used *(Personal Shoppers only)* **39/6**
R.A.F. ANTI-GLARE SUN SPECTACLES
Complete with strong case, **22/6** post free.

Terms to Flying Clubs

Lewis LIMITED

Illustrated leaflet on request. Trade supplied.

(Dept. F), 124 Great Portland St., London, W.1
Tel. MUSeum 4314. Grams., Aviakit, Wesdo, London.

Open all day Saturday.

AIRCRAFT ACCESSORIES AND ENGINES

A. J.W. (INSTRUMENTS), LTD.

ALL types of aircraft instruments overhauled. Special test instruments made to your requirements. Particulars on request of our Magnetizer, Demagnetizer and Strobeflash—compact—efficient and inexpensive.

A. J.W. (Instruments), Ltd., Gatwick Airport, Horley, Surrey. Tel. Horley 1420 and 1510 (Ext. 38, 105/6). [0268

ROLLASON AIRCRAFT AND ENGINES, LTD., CRO. 5151. For all Tiger Moth, Gipsy Major, Gipsy Queen and Gipsy Six spares. Specialists in the overhauling of Gipsy engines. [0131

LYCOMING 50 h.p. complete with prop. New condition. £45. Cirrus Min., time exp. £65. Queen II, 200 hours since new. £120. Proctor propeller, low time. £45. Box No. 0732. [6880

PHILLIPS & WHITE, LTD., offer from stock Instruments and instrument parts. Navigational equipment, electrical components, airframe parts and hydraulic components and parts. Engine spares for de Havilland Gipsy Major and Queen series, also Armstrong Siddeley Cheetah IX, X, XV spares. Stock lists available. 61, Queen's Gardens, London, W.2. Tel.: Ambassador 8651, 2764. Cables: Gyair, London. [0466

ENGINE Overhauls. Hants and Sussex Aviation Limited offer Britain's most comprehensive engine complete overhaul service, magneto overhaul service, and component and spares supply. De Havilland Gipsy range, Armstrong Siddeley Cheetah range, Cirrus range, Lycoming, Scarab and Continental. Most types available on exchange. Engines, components and spares shipped to all parts of the world. Address: The Airport, Portsmouth. Phone 73947. [0711

PUBLIC ANNOUNCEMENTS

AIR TRANSPORT ADVISORY COUNCIL

THE AIR TRANSPORT ADVISORY COUNCIL give notice that they have received the undermentioned applications to operate scheduled air services:—

APPLICATION No. 1368. From British European Airways Corporation of Keyline House, Ruislip, Middlesex, for a Normal Scheduled Service with Viscount aircraft and later with Vanguard aircraft for the carriage of passengers, supplementary freight and mail between London and Klagenfurt with an intermediate optional traffic stop at Munich at a frequency according to traffic demand for a period of 10 years, from 1958.

APPLICATION No. 1369. From Eagle Airways, Ltd., of 40, Edgware Road, London, W.2, for a Normal Scheduled Service with Viscount aircraft for the carriage of passengers, supplementary freight and mail between London Airport and Reykjavik with intermediate optional traffic stops at Manchester and/or Prestwick at a frequency of two return flights per week increasing according to traffic demand for a period of 10 years, from October, 1957.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on 30th July, 1952. Any representations or objections with regard to these applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [6871

SHORT AVIATION
for
D. H. RAPIDE SPARES
BRAND NEW—EX STOCK—IMMEDIATE DELIVERY
HIGHLY COMPETITIVE PRICES
TIGER MOTH SPARES
IN QUANTITY—EX STOCK—BRAND NEW—VERY LOW PRICES
R. A. SHORT AVIATION, WHYTELEAFE, SURREY. PHONE: UPLANDS 8211/2

OUR HELICOPTERS FLY ALL OVER THE WORLD
Our fleet of helicopters is at your disposal anywhere in the world, any time.
We also run a training school for pilots and engineers on Bell 47 and Sikorsky S55 helicopters Ask for further details from:
OSTERMANS AERO, STOCKHOLM 7, SWEDEN
Cables: Ostermanaero, Stockholm

UNIVERSAL FLYING SERVICES LTD.
A.R.B. APPROVED FOR
C. of A. OVERHAULS
REPAIRS
CONTRACT MAINTENANCE
ALSO
FLYING TUITION
M.C.A. APPROVED COURSES
AIRCRAFT HANGARAGE
FAIROAKS AERODROME
CHOBHAM (WOKING) SURREY
TEL: CHOBHAM 375

SENIOR STRESS ENGINEERS
Starting Salaries £1200/£1700
Qualified men interested in employment within the above starting range, carrying scope for advancement, should enquire in confidence for further details.
Modern housing available convenient to Works, Schools, and Shopping Centres.
Duties cover work on special projects associated with Aircraft Design and Development. Previous experience in this field is not essential for applicants with sound technical background.
Send full particulars age, experience and convenient dates for interview to **S/A. Box No. 0592, c/o "Flight".**

AMERICAN K20 AIRCRAFT CAMERA in fitted carrying case F4.5 lens
£15 . 0 . 0
Films available. K24, F24, F52, K8AB and other cameras and all accessories available from stock write:—
Air Survey Dept.
Harringay Photo Supplies
423 Green Lanes - - London, N.4
MOUntview 5241/2

The . . .
British Air Line Pilots Association
95 MOUNT STREET, W.1
Tel.: Grosvenor 6261
Membership open to all commercial and Service Pilots. For full details concerning objects and particulars of membership please write to Secretary

PUBLIC APPOINTMENTS

MINISTRY OF TRANSPORT AND CIVIL AVIATION

AIR TRAFFIC CONTROL OFFICERS

APPLICATIONS are invited from men and women for Grade III posts with prospects of pensionable appointment. Age at least 23 and under 35 on 1st June, 1957. Candidates must have had a good general education, i.e. normally, General Certificate of Education, with passes in English and mathematics or science or an equivalent qualification. Necessary experience, preferably recent, is (i) as aircrew in civil air transport, preferably as pilot or navigator with experience in the United Kingdom, or (ii) as pilot or navigator in H.M. Forces, preferably with considerable air traffic control experience; but candidates without aircrew experience will be considered if they have considerable practical experience of air traffic control duties. The following will be advantages (i) A.F.R.Ae.S., (ii) pilot's or navigator's licence issued by the Ministry, (iii) good knowledge of civil aviation legislation and practice, (iv) knowledge of radio and radar aids, (v) knowledge of a modern European language. Air Traffic Control Officers are required to serve anywhere in the United Kingdom, and are liable to tours of duty overseas. Starting salary (London): £675 at age 23 to £970 at age 30 or over. Maximum salary for Grade III £1,315. Somewhat lower in Provinces. Women's salaries at present somewhat lower but being improved under Equal Pay Scheme. Promotion prospects to Grade II (maximum salary £1,550) and Grade I (maximum salary £1,690). Particulars and application forms from the Secretary, Civil Service Commission, Burlington Gardens, London, W.1. quoting No. 4735/57. Complete applications should be returned by 9th August, 1957 [6868

ASSISTANT Engineers Grade II required by EAST AFRICA HIGH COMMISSION Directorate of Civil Aviation on probation for pensionable employment. Gross salary according to age and qualifications up to £1,173 a year in scale £813 rising to £1,341 a year. Outfit allowance £30. Free passages. Liberal leave on full salary after each tour 30-36 months. Candidates, who should hold at least two second year and preferably one third year C. & G. Certs. in Telecomms. Principles or Radio, must have had a minimum of three years' experience in the erection and maintenance of ground station transmitters, radio and radar navigational aids and aerial systems. They should have up-to-date knowledge of workshop practice and a knowledge of teleprinter and perforator equipment or Diesel electric power plant maintenance would be an advantage. Write to the Crown Agents, 4 Millbank, London, S.W.1. State age, name in block letters, full qualifications and experience and quote M2C/42260/FE. [6864

AIRCRAFT FERRYING

FOR delivery and ferrying of aircraft contact Overseas Air Transport, Ltd., 22, Broad Street, St. Helier, Jersey, Channel Islands. [6723

AERIAL PHOTOGRAPHY

MORSE Film Developing Units and Film Dryers; Continuous Film Printers; Argon and Mason Contact Printers; Water Supply Kits; Glazing Machines; F.24 Spiral and Spool Developing Outfits; K.17; F.52; F.49; and F.24 Cameras, Mounts, Lenses, Magazines, Controls, Vacuum Pumps, Motors and Spares for above Cameras; 16 m/m and 35 m/m Cameras, Projectors and Spares. Also large quantity of Aerial Film (all sizes). A. W. Young, 47, Mildenhall Road, London, E.5. Tel.: AMHerst 6521. [0290

COAXIAL CONNECTORS UG TYPE
21-B/U, 58/U, 290/U etc.
according to JAN and MIL specifications for aircraft etc.
Full list available. Send your requirements.
N.A.R. Agencies Ltd.
40 King's Road, London, S.W.3

AIRCRAFT SPRING WASHERS

TO B.S. SPECIFICATION S.P.47
CROSS MFG. CO. (1938) LTD., COMBE DOWN, BATH

AIRCRAFT SERVICING

REPAIRS and C. of A. overhaul for all types of aircraft.—Brookland Aviation, Ltd., Civil Repair Services, Sywell Aerodrome, Northampton. Tel.: Moulton 3251. [0307

BUSINESS AND PROPERTY

AERODROME FOR RENT

BETWEEN Swindon and Oxford, Grass Aerodrome, size 72 acres, unrestricted approaches, landing run of ¼ mile one way and over 600 yds. the other. One hangar of over 5,000 sq. ft., small office building and clubhouse building. Rent approximately £1,500 p.a. Apply Box No. 6419. [0270

MARSHALL

AIRPORT WORKS CAMBRIDGE

DESIGN & DRAWING OFFICE

SENIOR STRESS ENGINEERS

Required for Interesting Work on

MODERN AIRCRAFT INCLUDING NEW PROJECTS

Aircraft experience desirable but not essential.

Excellent opportunities for right type.

New housing available if required.

Applications in first instance to PERSONNEL MANAGER

BALL BEARINGS

NEW Ball and roller bearings, over 4,000,000 in stock in more than 4,000 types. Britain's largest stocks. Stock list available. Claude Rye, Ltd., 895-921 Fulham Road, London, S.W.6. RENown 6174 (Ext. 24). [0420

CLOTHING

R.A.F. officers' uniforms purchased; good selection of R.A.F. officers' kit for sale, new and reconditioned.—Fishers, Service Outfitters, 86-88 Wellington Street, Woolwich. Tel.: Woolwich 1055. [0567

CONSULTANTS

R. K. DUNDAS, LTD., have been giving the correct answer to aviation problems for twenty years. Technical. Purchasing Operations. Marketing. 59, St. James's Street, London, S.W.1. HYDe Park 371. [0560

CONTACT LENSES

MODERN CONTACT LENSES CENTRE 7(D.I), Endsleigh Court, W.C.1. Deferred Terms. Booklet sent. [0342

HELICOPTERS

HELICOPTER Charter. U.K. and Overseas. Autair, Ltd., 75 Wigmore Street, London, W.1. Telephone: Welbeck 1131. [0020

PACKING AND SHIPPING

R. AND J. PARK, LTD., 143/9 Fenchurch St., E.C. Tel.: Mansion House 3083. Official packers and shippers to the aircraft industry. [0012

MISCELLANEOUS

PARACHUTE, nylon, seat type in new condition. £30. Box No. 0737. [6882

CAPACITY AVAILABLE

KELLERING and profile milling in all metals. Send us your die blocks to copy from wood or plaster masters. Up to 5ft by 8ft max. size. We are die copiers to the trade.

ARMYTAGE BROS. (KNOTTINGLEY), LTD., The Foundry, Knottingley, Yorkshire. Tel.: Knottingley 2046. [0975

MINISTRY APPROVED COURSES FOR

COMMERCIAL PILOT INSTRUMENT RATING

All subjects for professional licences and ratings including Academic, Technical, simulated and practical flying. Home Study excellent alternative

- Individual coaching
- Refresher Courses
- Officials appointed by the Institute of Army Education for Forces Correspondence Scheme

Full details from your Station Education Officer, or

London School of Air Navigation Ltd.

33 Ovington Sq., Knightsbridge, London S.W.3

KEN 8221 Flying Base, Croydon Airport

LICENSED RADIO ENGINEER

required

for D.H. Heron and Dove Fleet

Apply

MORTON ENGINEERING SERVICES LTD.

Croydon Airport, Surrey

DESIGNERS
DRAUGHTSMEN
ENGINEERS
TECHNICIANS

Men with the right capabilities and qualifications are required for a programme of work on the design and development of high performance and supersonic aircraft.

Depending upon the appointment an Ordinary or Higher National Certificate, Degree or equivalent qualification is required. Previous experience of aircraft work is preferred but is not essential.

A new design office, laboratories, and wind tunnel will be completed in the near future and the posts advertised present opportunities to enter a strong design team with excellent working conditions in pleasant surroundings.

AERODYNAMICS Performance, Stability Control.

STRENGTH CALCULATIONS Static and Dynamic stressing and design calculations, fatigue, aeroelasticity.

SERVOMECHANISMS Electrical-mechanical aerodynamic control systems.

FLUTTER AND DYNAMICS Calculations and Test analysis involving use of analogue and digital computers.

STRUCTURAL TEST Static and Dynamic Testing including heat effects of components and complete airframes.

SYSTEMS TESTING Functional and reliability testing of air, hydraulic, fuel and electrical systems.

STRUCTURES DESIGN Detail design of aircraft structural components.

SYSTEMS DESIGN Detail design of hydraulic, fuel, and air systems.

ELECTRICAL ELECTRONIC INSTALLATIONS Design of installations of radio, navigational and other military equipment of latest types and specifications.

Write giving full particulars, quoting ref. number 3445, to:—

Personnel Officer,

VICKERS-ARMSTRONGS (AIRCRAFT) LTD South Marston Works, Nr. Swindon, Wilts.

T3421

TUITION

AIR SERVICE TRAINING

The only fully equipped private School of Aviation. Specialist staff, comprehensive equipment and full residential and recreational facilities within the School ensure the soundest training for an aviation career.

M.T.C.A. APPROVED COURSES

for private and commercial pilots' licences and maintenance engineers' licence in categories "A" and "C".

HELICOPTER COURSES

for private and professional licences. Details available from the Commandant.

AIR SERVICE TRAINING, LTD.

Hamble, Southampton. Tel.: Hamble 3001/9. [0970

CIVIL PILOT/NAVIGATOR LICENCES

AVIGATION, LTD., provides full-time, or intermittent instruction and postal tuition, or a combination of any of these methods to suit individual requirements for the above licences. Classroom instruction can be provided for A.R.B. General, certain Specific Types and Performance Schedule examinations. Link training Dept. at MONarch 1364.
FOR full details apply to The Principal,

AVIGATION, LIMITED

30 Central Chambers, Ealing B/Way, London, W.5. Tel.: Ealing 8949. [0248

A SUCCESSFUL career for your son.

AERONAUTICAL, technical and practical training for all branches of aeronautical engineering. Diploma course leads to executive appointments in civil aviation design and development, draughtsmanship, maintenance, etc. Extended courses to prepare for A.F.R.Ae.S., and A.M.I.Mech.E. examinations. Write for prospectus to Engineer in Charge, College of Aeronautical Engineering, Chelsea, London, S.W.3. FLAxman 0021. [0019

SOUTHEND - ON - SEA MUNICIPAL AIR CENTRE AND FLYING SCHOOL.
COMPREHENSIVE training for all pilots' licences, ratings and endorsements.
SPECIAL facilities for Instrument, Night Flying and Commercial Pilot Licences.
CHIPMUNK AIRCRAFT. Link training to full instrument rating standard.
NO entrance fee or subscriptions.
M.T.C.A. approved 30-hour course.
MUNICIPAL Airport, Southend-on-Sea, Essex. Rochford 56204. [0453

CANADAIR LIMITED

OFFERS OPPORTUNITIES IN MONTREAL

for

AERODYNAMICISTS
Requires B.Sc. in Aero Engineering or equivalent plus experience in performance analysis, stability and control, and/or air loads. Several SENIOR POSITIONS are open to the more experienced applicants.

PROJECT DESIGN ENGINEERS
Requires B.Sc. or H.N.C. plus apprenticeship and six years' experience in preliminary design of airframe structures, installations, and systems on new aircraft projects. SENIOR POSITIONS are also open in this category.

MATHEMATICIANS FOR DIGITAL AND ANALOGUE COMPUTING
Requirements include post-graduate qualifications in mathematics plus experience in planning and programming for computors including development of methods and applications. Experience in the aircraft industry is preferred but not essential. These positions offer fine opportunities for advancement in a fast growing computing group.

FLUTTER, VIBRATION, INSTRUMENTATION AND ACOUSTICAL ENGINEERS FOR ANALYSIS AND/OR TESTING
Requires a degree in engineering or physics, or H.N.C., plus apprenticeship and some experience in the applicable field for solution of aeroelastic problems by mathematical analysis and/or laboratory testing.

FLIGHT TEST INSTRUMENTATION ENGINEERS
Requires B.Sc. or H.N.C. plus apprenticeship, and several years' experience on design and development instrumentation for flight testing of aircraft in developmental stages.

ELECTRICAL DESIGN ENGINEERS
Positions available for broad range of electrical design engineers. A B.Sc. or H.N.C. plus apprenticeship or equivalent is required with a minimum of four years' or more experience in applicable field. SEVERAL SENIOR OPENINGS are available for men with eight or more years' experience. Positions involve design of main electrical supply systems, including load analysis; also design of circuitry and installations of major aircraft systems. Experience in the design of alternating current systems highly desirable.

SENIOR ELECTRICAL DRAUGHTSMEN
Aircraft electrical draughtsmen with extensive experience in aircraft circuitry, electrical installation design are required in the aircraft electrical design section.

AIRCRAFT DRAUGHTSMEN
Men with 4-12 years' experience in design of aircraft structures, systems and related equipment are required. Some portion of draughting experience in related engineering fields would be acceptable and judged on its applicability to assignment.

Accepted applicants will receive:

★ **Excellent salaries.**
★ **Liberal moving assistance.**
★ **A full programme of employee benefits.**

U.K. INTERVIEWS ARE BEING CONDUCTED NOW

Please send details of qualifications and experience to:

J. H. DAVIS,
European Representative of Canadair Limited,
190 Piccadilly, London, W.1.

TUITION

SURREY Flying Club, Croydon Airport, M.C.A. approved for private pilots' licences. Open seven days a week. Croydon 7744. [0293

FREE! Brochure giving details of courses in all branches Aero Engineering covering A.F.R.Ae.S., M.C.A. exams, etc. Also courses for all other branches of engineering. Write: E.M.I. Institutes, Dept. F26, London, W.4. (Associated with H.M.V.) [0964

A.F.R.Ae.S., A.R.B. Certs., A.M.I.Mech.E., etc., on "no pass, no fee" terms. Over 95 per cent successes. For details of exams and courses in all branches of Aeronautical work, Navigation, Mechanical Engineering, etc., write for 144-page handbook—free.—B.I.E.T. (Dept. 702), 29 Wright's Lane, London, W.1. [0707

LEARN to fly, £30; Instructors' Licences and Instrument flying, for £3 10s. per hour. Night flying £5 per hour. Residence 6 guineas weekly. Approved M.C.A. Private Pilot's Licence course. Specialized course for Commercial Pilot's Licence.—Wiltshire School of Flying, Ltd., Thruxton Aerodrome (Andover Junction 1 hour 15 minutes from Waterloo), Hants. [0253

SITUATIONS VACANT

AEROPLANE and ARMAMENT EXPERIMENTAL ESTABLISHMENT BOSCOMBE DOWN

requires

SKILLED men to serve as:

INSTRUMENT and ELECTRICAL CRAFTSMEN
RADIO/RADAR and ELECTRONIC CRAFTSMEN
for laboratory and aircraft installations work
AIRFRAME and ENGINE FITTERS
for aircraft servicing and fitting of special equipment.
FITTERS and TURNERS
for Research Workshops.

RATE of pay on entry for 44 hour 5-day week, 182/4 plus 10/- merit lead or 182/4 plus 38/- merit lead according to experience. Prospects of re-assessment of rate within three months, any increase backdated to date of entry. Merit lead can rise to 70/-. Two weeks (88 hours) paid annual leave. Paid sick leave scheme.

APPLY giving details of apprenticeship and experience to Air Commodore (Civilian Adminstration Office), (F), A.&A.E.E., Boscombe Down, Amesbury, Wiltshire. [6870

LICENSED Engineers required. X Electrical, Ignition and Instruments. To take charge small workshops. Surrey. Box No. 0380. [6827

REQUIRED, services of ground engineer holding A, B and C Licences, to take charge of C. of A. overhaul work on light aircraft. Wiltshire School of Flying, Thruxton Aerodrome, Andover. [0254

MARSHALL

AIRPORT WORKS CAMBRIDGE

Vacancies at Cambridge and "on site" for

SKILLED AERO ELECTRICIANS

Required for installation and testing Electrical Systems in Civil and Service Aircraft.

Also

SKILLED AIRFRAME FITTERS

Good Average Earnings.

Single Lodging Accommodation Available.

Write, Call or Phone:
Cambridge 56291—ext. 36.
EMPLOYMENT OFFICER

ROLLS-ROYCE
(Aero Division)

have vacancies at their

DERBY ESTABLISHMENT

for

AIRCRAFT PERFORMANCE ENGINEERS

with a Degree or Higher National Certificate standard of education.

The work includes the performance assessment and operational analysis of a very wide and interesting range of projected applications of all the Company's aero-engines, both civil and military.

The positions are progressive, in an expanding department, and will involve the supervision of computer analysis. Previous experience in similar work is preferable but not essential and attractive salaries will be paid to successful applicants, depending upon age and experience.

Please write in the first instance for an application form to:

The Manager,
Technical Administration,
Rolls-Royce Limited,
(Aero Division),
P.O. Box 31, Derby.

HAWKER AIRCRAFT LTD

requires

DRAUGHTSMEN

DESIGNER DRAUGHTSMEN
DETAIL DRAUGHTSMEN
SENIOR DRAUGHTSMEN
JUNIOR DRAUGHTSMEN

to work now on a supersonic strike aircraft and on future projects.
Qualifications desirable — ability essential.

Bright young men, not over 25, ex-National Service, and who are qualified to National Certificate standard and have good practical experience are wanted as–

TRAINEE DRAUGHTSMEN

If you wish–

To join a Company with a splendid world-wide technical reputation.
To be working soon in a fine new Drawing Office.
To work a 5-day week and enjoy good sports and social facilities.
To get a good commencing salary with Superannuation under the Pension and Life Assurance Scheme of the Hawker Siddeley Group.
To have a good career with advancement on merit—

Write, or send a postcard for an application form to

THE PERSONNEL SUPERVISOR,

HAWKER AIRCRAFT LTD

KINGSTON-ON-THAMES · SURREY *Tel: KINGSTON 1044*

SITUATIONS VACANT

TURBINE SALESMEN

VACANCIES exist in the Sales Branch of the manufacturers of small gas turbines for the following specialists:

(1) Industrial gas turbines: to create a new market in the industrial and marine field, preference will be given to previous experience, with Diesel engine sales.

(2) Aviation sales, with preference given to specialists in marketing ground servicing Airfield equipment.

THE above two vacancies are required to be filled immediately, a knowledge of gas turbines is essential and preference will be given to applicants with commissioned Service experience. Duties may cover considerable travelling but initially the appointment will be based on London.

APPLY in writing, stating experience:

Engine Sales Manager,

Blackburn & General Aircraft, Ltd.,

43, Berkeley Square,

London, W.1. [6875

STRESSMEN (Senior and Intermediate) required for interesting programme of airframe structural work. University degree or H.N.C. in aeronautical engineering and with previous experience in this sphere. Details of experience and qualifications to the Personnel Manager, Folland Aircraft, Ltd., Hamble, Hants. [6790

ENGINEERS, licensed and unlicensed, required at Birmingham and Wolverhampton Airports, for Dakota and Rapide Aircraft. Single licence considered. Good opportunity, with accommodation if necessary, to suitably qualified applicant. Apply: Manager, Don Everall (Aviation), Wolverhampton Airport. [6873

GHANA PUBLIC SERVICE COMMISSION

AIR Traffic Control Officer (Grade II). To carry out watch-keeping duties in the aerodrome control service at Accra Airport and assist with other air traffic and associated services. Candidates must have successfully completed a recognised course in Air Traffic Control or gained aircrew experience as pilot, navigator or radio officer. Appointment on contract for one tour of 18-24 months duration in the first instance. Salary range £990-£1,230 p.a. with a gratuity at the rate of £8 6s. 8d. to £12 10s. for each month of service. Outfit allowance of £30-£60 on first appointment. Free first-class passages. Quarters at rental of £60-£90 a year according to salary. Generous home leave. Taxation at low local rates.

APPLY for further particulars and application form from the Director of Recruitment, Ghana Office, 13 Belgrave Square, London, S.W.1, giving briefly age, qualifications and experience. [6877

HONG KONG AIRCRAFT ENGINEERING CO., LTD., have a vacancy for an engineering estimator in their Production Planning Dept. Essential qualifications include a general aircraft engineering training and experience of practical work preferably overhaul, with wide experience estimating overhaul work on airframes, engine and ancillaries knowledge desirable additions; but main emphasis on airframes. Types to be estimated include civil and military aircraft up to DC6. Monthly salary £106 at commencement plus £36 marriage allowance to married man. Sickness and provident fund operated, accommodation and essential furnishings provided. Three-year contract initially, but position permanent. Apply giving full details precise training and experience including positions previously held to Matheson & Co., Limited, 3 Lombard Street, London, E.C.3, when full details of contract will be sent to suitable applicants. Final interview London. [6804

Centres of aeronautical progress

LONDON | **EAST COWES** I.O.W

STRESS ENGINEERS • AERODYNAMICISTS

DRAUGHTSMEN and other technicians

. . . with the necessary technical and scientific experience enabling them to meet the challenge of new aeronautical problems, will find ample scope for their ability and ambition in the London and Osborne, I.O.W. design offices of Saunders-Roe Ltd. *Assistance with accommodation can be offered to those selected to work at Osborne.*

Please apply stating age, experience, qualifications and Ref. F/38 to: PERSONNEL OFFICER

SAUNDERS-ROE LTD. EAST COWES, I.O.W.

DUNLOP RUBBER COMPANY AERO TYRE DIVISION

Offer appointments for Tyre Design and Development work in this very active branch of the tyre industry. The work is interesting and varied and there are good prospects of advancement within the organisation. Applicants should be aged 25-35 and have Degree in Engineering or similar qualification; some industrial experience is preferred but not essential. Please write, giving experience and salary required, to

PERSONNEL MANAGER (AT),
FORT DUNLOP,
ERDINGTON,
BIRMINGHAM, 24

SITUATIONS VACANT

REQUIRED, aircraft engineer licensed in Category 'A' for D.H.114 (Heron).

APPLY: Chief Engineer, Dan-Air Engineering, Ltd., Lasham Airfield, Nr. Alton, Hants. [6867

MIDEAST AIRCRAFT SERVICE CO., Beirut, have vacancies for the following staff:

(a) An Electrical Engineer holding an ARB 'X' Licence, with experience in line maintenance on four engine types of aircraft such as Yorks and Viscounts.

(b) An Aircraft Production Engineer to take charge of the overhaul section carrying out Check IVs, IIIs, with an eventual manpower strength of approximately 200 men, and should be familiar with modern methods of aircraft production control and planning, work study and standard costing.

GOOD salary and allowances. Applications should be sent to Staff Manager (A.C.), B.O.A.C., Stratton House, Stratton Street, W.1. [6876

BRITISH OVERSEAS AIRWAYS CORPORATION have vacancies in their Training Unit at London Airport for the following:

NAVIGATION INSTRUCTORS to lecture pilots and station officers on navigational subjects. Essential qualifications: Passed technical examination for Flight Navigator's Licence or sufficient knowledge to pass the examination within a reasonable time. Previous lecturing experience. Ability to express navigational subjects clearly. Some practical navigational and stations operations procedure experience. Salary range £920-£1,190 per annum.

ENGINEER INSTRUCTORS to give instructions on aircraft electrical and instrument systems. Minimum qualifications required are technical knowledge to at least the standard required to obtain the appropriate 'X' licence or an appropriate City and Guilds Certificate, five years' experience in the maintenance and/or overhaul of aircraft electrical systems or instruments OR an apprenticeship in aeronautical engineering with two years' practical experience as above, a marked ability in expressing aeronautical engineering subjects verbally and in writing. In particular, a keen interest in the practical aspects of trade proficiency is necessary, coupled with the ability to demonstrate methods and procedures. Salary range £817. 10. 0d. per annum to £1,232. 10. 0d. per annum according to qualifications and experience.

ATTRACTIVE pension, insurance and leave schemes. Write, giving full details of experience to Assistant Staff Manager (Appointments), Recruitment Centre, B.O.A.C., London Airport. [6874

TECHNICAL Writer required for compiling servicing manuals, general instructional literature and copy writing. Must have the highest technical qualifications.

APPLY: The Secretary, Martin-Baker Aircraft Co., Ltd., Higher Denham, Nr. Uxbridge, Middlesex. Tel.: Denham 2214. [6866

AIRCRAFT Engineer, licensed in categories A and C, required for maintenance of flying school fleet comprising Austers, Magisters and Chipmunks. Opportunity for hard worker to build up small servicing section from scratch. Immediate vacancy. Applications in writing to Chief Flying Instructor, Elstree Aerodrome, Herts. [6872

AIRCRAFT Licensed Engineers required, who possess "A" and "C" licences on Yorks, for position of responsibility—Asst. Chief Engineers—Chief Inspector—for work in Beirut, Lebanon. Salary £2,150 to £2,700 per annum. Low income tax, family and own passages paid, medical scheme; apply: Trans-Mediterranean Airways, P.O.B.3018, Beirut, Lebanon. [6829

A VACANCY exists for a man, with aircraft instrument overhaul experience and some aircraft instrument installation maintenance experience, who is interested in the inspection, testing and quality control of instruments and some electronic and electrical equipment undergoing overhaul. Please apply to Chief Inspector, Field Aircraft Services, Ltd., Bovingdon Airport, Bovingdon, Herts. [6865

HONG KONG AIRCRAFT ENGINEERING CO., LTD., have vacancies for airframe overhaul engineers. Essential qualifications must include a general aircraft engineering training with not less than five years' experience on airframe overhaul of modern American type aircraft. Monthly salary £106 at commencement plus £36 marriage allowance. Sickness and provident fund operated, accommodation and essential furniture provided. Three-year contract initially, but position permanent. Apply giving full details precise training and experience including positions previously held to Matheson & Co., Limited, 3 Lombard Street, London, E.C.3., when full details of contract will be sent to suitable applicants. Final interview London. [6835

BOOKS, ETC.

"DEVELOPMENT of the Guided Missile," 2nd Ed. by Kenneth W. Gatland, F.R.A.S. Presents all the main information now available on the development of guided weapons in Britain, U.S.A., Germany, U.S.S.R., and elsewhere. Other chapters discuss guided missiles as instruments of research into the upper atmosphere and outer space, and as vehicles of interplanetary travel. An appendix shows the characteristics of 130 powered missiles known to have been designed or constructed. 15s. 0d. net, from all booksellers. By post 16s. 1d. from Iliffe & Sons, Ltd., Dorset House, Stamford Street, London, S.E.1.

A magnificent collection of beautifully reproduced aircraft photographs . . .

FLIGHT FLY-PAST

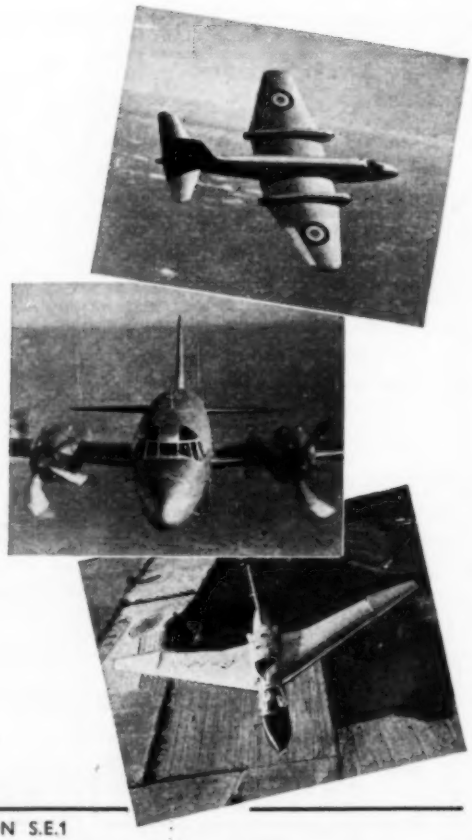
A Portfolio of Aircraft Photographs taken by "Flight" Cameramen

The work of "FLIGHT" cameramen is prized by enthusiasts throughout the world. The attractive portfolio contains an outstanding selection of their recent work, superbly reproduced. Includes 24 large plates, printed on high quality art paper.

7s. 6d. net. By post 8s. 5d.

Published for "Flight"

From Booksellers or direct from:—



'FLIGHT" · DORSET HOUSE · STAMFORD STREET · LONDON S.E.1

PROTECT YOUR HEARING from JET NOISE

BY WEARING **Nosonic** EAR DEFENDERS

THE *ANTICOUSTIC* and MALLOCK-ARMSTRONG COMPANIES, 204 HIGH STREET, GUILFORD, SURREY

INDEX TO ADVERTISERS

	Page
Abbey Panel and Sheet Metal Co., Ltd.	6
Alvis, Ltd.	Facing Edit. Page 118
Anticoustic Co.	54
Armstrong Siddeley Motors, Ltd.	Facing Edit. Page 106
B.B. Chemical Co., Ltd.	40
Bellman Hangars, Ltd.	16
Blackburn and General Aircraft, Ltd.	37
Boulton Paul Aircraft, Ltd.	11
Box No. 0592	49
Bristol Aircraft, Ltd.	Cover iv
British Air Line Pilots Association, Ltd. The	49
British European Airways	38
British Thomson-Houston Co., Ltd., The	41
Burnley Aircraft Products, Ltd.	14
Canadair, Ltd.	51
Cross Manufacturing Co. (1938), Ltd	48, 49
Crossley (Packings), Ltd., Henry	5
Curran, Ltd., John	45
De Havilland Engine Co., Ltd., The	Facing Edit. Page 107
Delaney Gallay, Ltd.	Between Edit. Pages 106-107
Docker Brothers	10
Dowty Equipment, Ltd.	Cover iii
R. K. Dundas, Ltd.	48
Dunlop Rubber Co., Ltd.	35, 53
Eastern Provincial Airways, Ltd.	47
Elliott Brothers (London), Ltd.	7
English Electric Co., Ltd., The	22, 47
Esso Petroleum Co., Ltd.	Facing Edit. Page 119
Fairey Aviation Co., Ltd., The	47, Facing Edit. Page 108
Firth and John Brown, Ltd., Thos.	13
Ford (Aircraft Components), Ltd., Frank	43
Garringtons, Ltd.	Cover ii
General Electric Co., Ltd., The	8
Graviner Manufacturing Co., Ltd., The	Facing Edit. Page 111
Hawker Aircraft, Ltd.	52
Harringay Photo Supplies	49
High Duty Alloys, Ltd.	Between Edit. Pages 106-107
Hong Kong Aircraft Engineering Co., Ltd., The	40
Hunting Percival Aircraft, Ltd.	Facing Edit. Page 110
Iliffe and Sons, Ltd.	44, 54
Imperial Chemical Industries, Ltd.	Between Edit. Pages 118 and 119
Jenks Brothers, Ltd.	42
Kigass, Ltd.	46
Kiveton Park Steel and Wire Works, Ltd.	42
Lewis, Ltd., D.	48
London School of Air Navigation	50
Magnesium Elektron, Ltd.	41
Maricon, Ltd.	42
Marshall's Flying School, Ltd.	50, 51
Martin-Baker Aircraft, Ltd.	Facing Edit. Page 109
Morton Engineering Services, Ltd.	50
Munro, Ltd., R. W.	44
Napier and Son, Ltd., D.	21, 46
N.A.R. Agencies, Ltd.	49
Newton Brothers (Derby), Ltd.	44
Oil Feed Engineering Co., Ltd.	15
Opperman, Ltd., S. E.	44
Orenda Engines, Ltd.	Between Edit. Pages 118 and 119
Osterman's Aero	49
Palmer Tyre, Ltd., The	9
Precision Rubbers, Ltd.	43
R.F.D. Co., Ltd.	17
Rists Wires and Cables, Ltd.	12
Roe and Co., Ltd., A. V.	18
Rolls-Royce, Ltd.	19, 51
Saunders-Roe, Ltd.	Cover i, 53
School of Gas Turbine Technology	46
Shackleton, Ltd., W. S.	48
Short Aviation, R. A.	49
Short Brothers and Harland, Ltd.	1
Sperry Gyroscope Co., Ltd.	36
Steel Stampings, Ltd.	46
Teddington Aircraft Controls, Ltd.	16
Thermal Control Co., Ltd.	45
Uhlhorn Brothers, Ltd.	46
United Aircraft Export Corporation	2, 3
Universal Flying Services, Ltd.	49
Vickers-Armstrongs (Aircraft), Ltd.	20, 50
Westland Aircraft, Ltd.	39
Williamson Manufacturing Co., Ltd.	4

Printed in Great Britain for the Publishers, ILIFFE & SONS LTD., Dorset House, Stamford Street, London, S.E.1, by SUN PRINTERS LTD., London, and Watford, Herts. *Flight* can be obtained abroad from the following: AUSTRALIA AND NEW ZEALAND: Gordon & Gotch, Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service, Ltd., Gordon & Gotch, Ltd. SOUTH AFRICA: Central News Agency, Ltd.; Wm. Dawson & Sons (S.A.), Ltd. UNITED STATES: Eastern News Co. Entered as Second Class Matter at the New York, U.S.A., Post Office.

Fokker
F.27 FRIENDSHIP

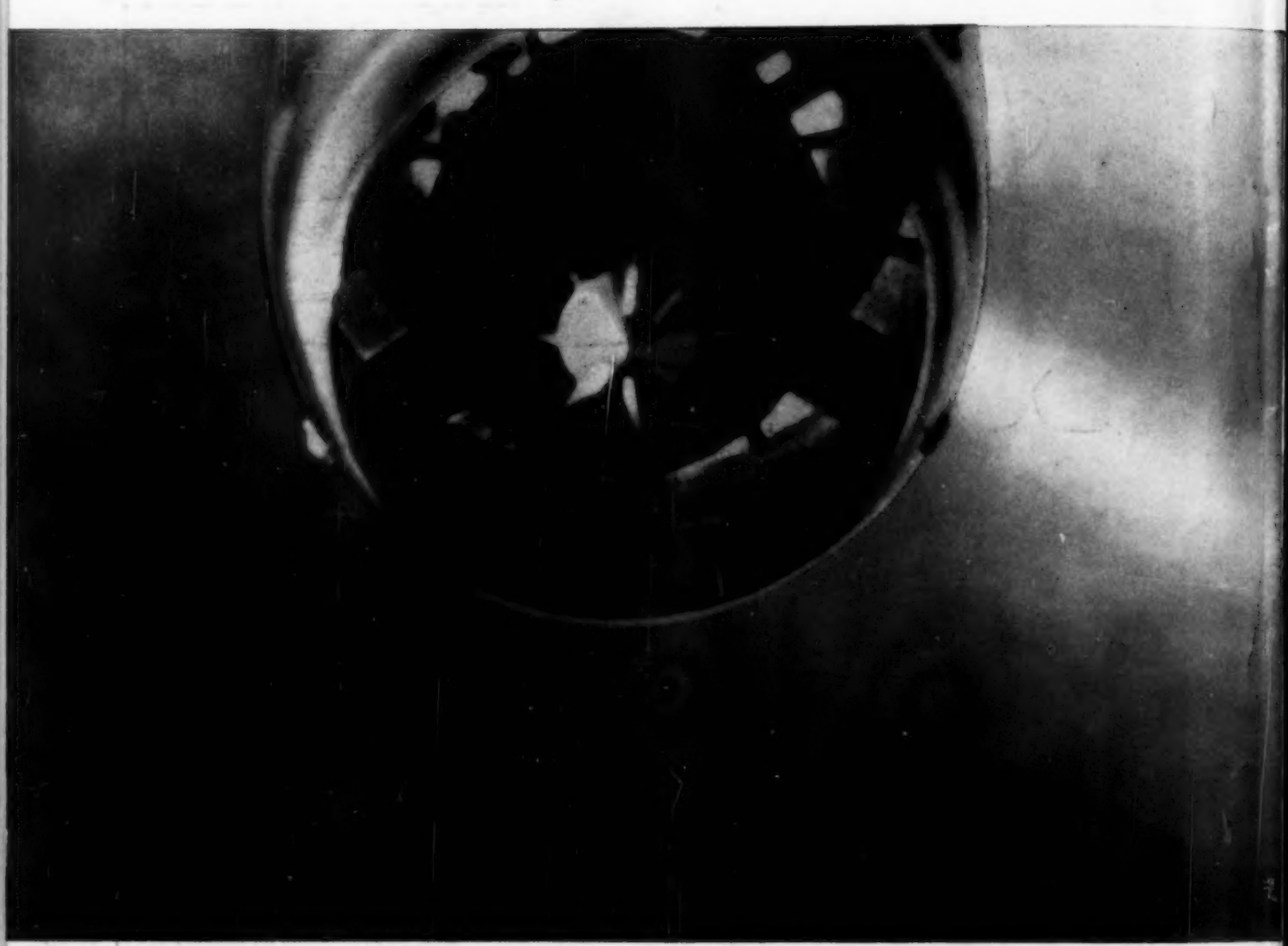
equipped with

DOWTY

UNDERCARRIAGES

CHELTENHAM

Member of the DOWTY Group



Flying on thin air comes naturally to the Thor, which is in its element at ultra-high speeds and altitudes

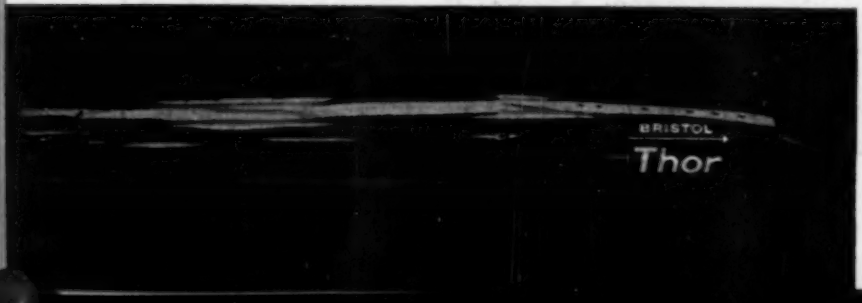
THOR RAMJET NOW IN PRODUCTION AND READY FOR SERVICE

BRISTOL AERO-ENGINES LIMITED have started quantity production of the Thor ramjet engine.

The Thor is suitable as a power unit both for manned (mixed power) and unmanned vehicles intended to operate at high Mach numbers.

The Thor achieves complete reliability in starting and in flight—essential in a guided missile. Well over 200 test vehicles have already been powered by the Thor. Many of these have flown higher, faster and farther than any other British ramjet vehicle. Bristol/Ferranti Bloodhound ground-to-air guided weapons are also powered by Thor type ramjet engines.

Bristol ramjets. The first Bristol ramjet flew in 1951. Since then Bristol have become firmly established as the leading British company in the ramjet field. Development continues, backed by the most complete facilities in Britain, including fully-equipped laboratories and test cells for simulating supersonic and stratospheric flight conditions.



BRISTOL
Thor

BRISTOL AERO-ENGINES LIMITED